# Part 23—Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

This change incorporates Amendment 23–46, Airworthiness Standards: Emergency Exit Provisions for Normal, Utility, Acrobatic, and Commuter Category Airplanes, adopted May 11, 1994. This amendment revises §§ 23.561, 23.783, 23.803, 23.807, 23.811, 23.813 and 23.815. Sections 23.805 and 23.812 are new.

Bold brackets enclose the most recently changed or added material in these particular sections. The amendment number and effective date of new material appear in bold brackets at the end of each affected section.

A formula was misprinted in A23.9 of Appendix A so page App. A–3 corrects this.

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Suggest filing this transmittal at the beginning of the FAR. It will provide a method for determining that all changes have been received as listed in the current edition of AC 00–44, Status of Federal Aviation Regulations, and a check for determining if the FAR contains the proper pages.

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## Appendix I—Seaplane Loads

**SUMMARY:** This final rule amends the emergency egress airworthiness standards for normal, utility, acrobatic, and commuter category airplanes. This amendment adds requirements for ditching and flightcrew emergency exits for these airplane categories, and provides alternative emergency exit requirements for commuter category airplanes that are consistent with the requirements for similarly sized small transport airplanes. This amendment is intended to ensure that emergency exits are available to all flightcrew members, that exits are available to all multiengine airplane occupants for emergency egress during an emergency landing in water, and to provide alternative exit requirements for commuter category airplanes consistent with the existing transport category airworthiness standards.

**FOR FURTHER INFORMATION CONTACT:** Mike Downs, Aerospace Engineer, Standards Office (ACE–110), Small Airplane Directorate, Federal Aviation Administration, Room 1544, 601 East 12th Street, Kansas City, MO 64106; telephone (816) 426–5688.

**SUPPLEMENTARY INFORMATION:**

## Background

This amendment is based on Notice of Proposed Rulemaking (NPRM) No. 90–20 (55 FR 35544, August 30, 1990). All comments received in response to Notice No. 90–20 have been considered in adopting this amendment.

Notice 78–14, published on October 10, 1978 (43 FR 46734), proposed interim airworthiness requirements for increased takeoff gross weight and passenger seating capacity of certain existing small, propeller-driven, multiengine airplanes. That rulemaking action resulted from a petition for rulemaking to allow certain small airplanes to be type certificated to maximum takeoff weights greater than 12,500 pounds without complying with the transport category type certification requirements of part 25. Special Federal Aviation Regulations (SFAR) 41 (44 FR 53723, September 17, 1979), which became effective October 17, 1979, resulted from Notice 78–14.

In the early 1980's, the FAA explored the feasibility of a new part 24 that would provide airworthiness standards for a new light transport category airplane. The proposal was withdrawn because it was not cost effective. SFAR 41 provides alternative type design standards for an airplane of the same gross weight that would be required to comply with part 25 airworthiness standards. Section 5 of SFAR 41 provides specific requirements for passenger entry doors and additional emergency exits. That section requires, in part, that the passenger entry door qualify as a floor-level emergency exit. For airplanes with a total seating capacity of 15 or fewer, that section requires, in addition to the passenger entry door, an emergency exit as defined in § 23.807(b), on each side of the cabin. For airplanes with a total passenger seating capacity of 16 through 23, that section required three emergency exits as defined in § 23.807(b), with one on the same side as the door and two on the side opposite the door.

SFAR 41 was amended (45 FR 25047, April 14, 1980) for clarification and editorial corrections. SFAR 41B (45 FR 80973, December 8, 1980) further amended the regulation to specify additional requirements for optional compliance with the International Civil Aviation Organization (ICAO), Annex 8, Part III, Airworthiness Standards, which apply to airplanes weighing 5,700 kg (12,566 pounds) or more.

After the expiration of SFAR 41B on October 17, 1981, and termination of the Light Transport Airplane Airworthiness Review, the FAA issued SFAR 41C (47 FR 35153, August 12, 1982), effective September 13, 1982. The amended SFAR: (1) eliminated the 12,500 pound maximum zero fuel weight restriction; (2) limited the number of passenger seats to 19 for those small propeller-driven, multiengine airplanes that operate at a certificated gross takeoff weight in excess of 12,500 pounds; and (3) relaxed the landing distance determination requirement, making it consistent with the similar requirements in part 23 and part 25. The wording of section 5 was amended, in part, to require that airplanes with a total passenger seating capacity of 16 through 19 be designed with three emergency exits, as defined in § 23.807(b), with one on the same side as the door and two on the side opposite the door.

and noted that additional rulemaking action would be initiated to enhance the cabin safety of commuter category airplanes if the proposals in Notice 83–17 were adopted.

As a result of Notice 83–17, amendment 23–34 (52 FR 1806, January 15, 1987) was adopted specifying minimum airworthiness standards for a new commuter category airplane. That final rule, in part, amended § 23.807 by adding a new paragraph (d) that required commuter category airplanes with a seating capacity of 15 or fewer to have an emergency exit on each side of the cabin in addition to the entry door; and commuter category airplanes with a total seating capacity of 16 through 19 to have three emergency exits, with one on the same side as the passenger entry door and two on the opposite side. Those requirements were substantively identical to the requirements in SFAR 41C.

As a result of Notice 86–19, amendment 23–36 (53 FR 30802, August 15, 1988) was adopted to provide upgraded airworthiness standards for cabin safety and occupant protection for part 23 airplanes.

Since final action to incorporate commuter category airplane airworthiness standards into the FAR had not been completed at the time Notice 86–19 was published, requirements for commuter category airplanes were not specifically addressed in the proposals of that notice. The proposals in Notice 86–19 were formulated to be compatible with the commuter category airplane cabin safety airworthiness standards that were adopted in amendment 23–34, with the exception of the requirements for dynamic testing of seats and the requirements for shoulder harnesses at the passenger seats. The cabin safety standards adopted by amendment 23–36 were formulated considering both the public comments to Notice 86–19 and the changes to part 23 adopted by amendment 23–34. The requirements for the number of emergency exits in commuter category airplanes, as adopted by amendment 23–34, were not changed by amendment 23–36. The commuter category final rule moved the requirements in § 23.807(d)(3) to a new § 23.811(b), and the requirements of § 23.807(d)(4) were moved to a new § 23.813.

The intent of section 5 of SFAR 41 was to require an additional emergency exit (above the requirements for normal category airplanes) for airplanes with a total seating capacity, including pilot seats, of 12 to 15; therefore, when an airplane with a seating capacity of 11 or fewer, including pilot seats, was certificated to the airworthiness standards of SFAR 41, the emergency exit requirements in § 23.807 for normal category airplanes were applicable. Since the amendment of the emergency exit standards of § 23.807(d)(1)(i), the FAA has reconsidered the number of exits required for commuter category airplanes with a cabin seating capacity of fewer than 9 passengers. Section 23.807(d)(1) is applicable to every commuter category airplane, including those airplanes with a total passenger seating capacity of 9 or fewer. This section increases the level of cabin safety requirements for commuter category airplanes.

Since incorporation of amendment 23–34 into part 23, airplane manufacturers and modifiers have petitioned the FAA for exemption from § 23.807(d)(1)(i) or § 23.807(d)(1)(ii). Those standards require that: commuter category airplanes with a total passenger seating capacity of 15 or fewer have an emergency exit on each side of the cabin in addition to the passenger entry door; and commuter category airplanes with a total passenger seating capacity of 16 through 19 have three emergency exits in addition to the passenger entry door, with one emergency exit on the same side as the door and two exits on the opposite side. Frequently, those petitions have noted the differences in the requirements of § 23.807(d)(1) and the emergency exit requirements for similarly sized transport category airplanes. Section 25.807(c)(1) requires, in part, that transport category airplanes with a passenger seating capacity of 19 passengers or fewer provide at least one emergency exit on each side of the fuselage and that the main entry door may be considered one of the emergency exits when it meets the requirements of §§ 25.807(c)(1) and 25.783.

The petitioners, in general, have proposed to provide the number of emergency exits required by § 25.807(c)(1) for transport category airplanes instead of complying with the requirements of § 23.807(d)(1). In support of these petitions, the petitioners point out that their commuter category airplanes have compensating features that include a variety of other cabin safety provisions and meet the higher levels of safety afforded by small transport category airplanes. Other cabin safety provisions include larger exits, wider aisles, emergency lighting and additional exit marking features, all of which exceed the current requirements

These additional airworthiness requirements are important factors in minimizing the time required for occupants to safely exit the airplane through a limited number of exits. As an alternative, this final rule allows commuter category airplanes to comply with emergency exit requirements and other cabin safety standards that are substantively the same as those for similarly sized transport category airplanes.

This final rule amends the emergency exit requirements to provide the following: (1) additional emergency landing requirements that give the airplane occupants every reasonable chance of escaping serious injury in a survivable crash landing; (2) emergency exit size and step up/step down limitations that enable the airplane occupants to readily pass through the exits; (3) emergency exit marking requirements that ensure the exits can be identified easily in an emergency; (4) emergency lighting requirements that ensure adequate lighting for rapid egress from the airplane; and (5) wider aisles and additional emergency exit access requirements that ensure the airplane occupants have a path to the available emergency exits.

This final rule also adopts new requirements for emergency exit ditching provisions for multiengine airplanes that are type certificated to the airworthiness standards of part 23. The FAA anticipates an increase in the use of multiengine normal and commuter category airplanes in overwater operation. Airports located near large bodies of water have increased the number of departures and approaches that are conducted over water. Since ditching provisions are critical for occupant egress following an emergency landing in water, this proposal would require that the airplane design provide the airplane occupants with a means of exiting the airplane following an emergency landing in water.

Further, this final rule adopts a new airworthiness standard to require that, in emergency landings, emergency exits are readily available to crewmembers when the airplane is configured in a manner that makes the passenger emergency exits inaccessible to the crew. The FAA has previously required additional emergency exits for normal category or commuter category sized airplane designs, where the cabin interiors were configured with cargo nets or other barriers that blocked crewmember access to the passenger emergency exits. Although § 135.87(c)(7) requires at least one emergency or regular exit to be available for crew egress in certain airplanes used in cargo-only operations, there is no such requirement in part 23. This newly adopted requirement is also similar to the standard that is used for transport category airplanes.

## Discussion of Comments

### *General*

Interested persons were invited to participate in the development of these final rules by submitting written data, views, or arguments to the regulatory docket on or before February 26, 1991. Five commenters responded to Notice No. 90–20. Minor technical and editorial changes have been made to the proposed rules based on relevant comments received and after further review by the FAA.

One commenter expresses support for the entire proposal without making any specific comments. Another commenter provides comments only to specific proposals. One commenter feels that the commuter category requirements of part 23 already provide an adequate level of safety and asks for an explanation of why the FAA is using part 25 requirements in part 23. This requested explanation can be found in the background section above.

One commenter expresses general agreement with the objectives of the rulemaking and discusses the factors that the commenter considers important to the rapid evacuation of an airplane. This commenter lists those factors as exit availability, adequate exit size, reasonable step up and step down criteria at emergency exits, and illumination of the area immediately outside the exit. The FAA agrees that these factors are also important but questions the relative significance the commenter ascribes to them. The commenter did not submit any supporting data for the comment.

One commenter supports the addition of the small transport category airplane safety features of part 25 to part 23 commuter category airplanes, but strongly opposes tying these features to a reduction in the number of emergency exits. This rulemaking action provides alternative emergency exit requirements

*Proposal 2.* This proposal would add a downward inertia load requirement to the emergency landing ultimate static load factors when an applicant for type certification chooses to comply with the alternate emergency exit requirements of § 23.807(d)(4). This is intended to ensure a specific minimum download airframe strength to protect occupants from structural failures that could prevent their exiting the airplane through the emergency exits or the passenger entry door after an emergency landing.

One commenter believes the 6g downward force is excessive for part 23 airplanes. The FAA disagrees. In the 1970's, the FAA and the National Aeronautics and Space Administration (NASA) conducted considerable research concerning the crash dynamic characteristics of small general aviation airplanes. NASA conducted a test series of 21 controlled full-scale impact tests on single-engine and twin-engine general aviation airplanes. Results from those tests provided a substantial qualitative and quantitative data base regarding the crash behavior and occupant impact protection characteristics of small general aviation airplanes. The results of the research and tests revealed that the downward force occurring during the full scale impact tests were in excess of 6g in most cases; therefore, the 6g downward inertia load factor was proposed to ensure a minimum download requirement.

One commenter recommends higher downward inertia loads and a correspondingly higher descent velocity, which was proposed as an alternate approach to establishing the static downward load factor. The FAA disagrees. Although downward load factors may be greater than 6g during emergency landing conditions, the FAA intends to make the airworthiness standards for commuter category airplanes consistent with those for small transport airplanes; therefore, the 6g downward load factor will remain as a minimum requirement. Accordingly, that portion of § 23.561(b)(2)(iv) that specifies the use of any lesser force is deleted in the final rule. The removal of this lesser force from the proposed rule further standardizes the alternate cabin safety and emergency exit requirements of part 23 commuter category with that of part 25 small transport airplanes. The alternative downward force was similarly deleted from part 25. This proposal is adopted with the aforementioned change.

*Proposal 3.* This proposal would move certain requirements for commuter category airplane passenger entry doors and associated integral stairs from § 23.807(d)(1) to a new § 23.783(f), and add size and shape requirements for the passenger entry door. The final rule clarifies those standards that apply to the passenger entry doors of any commuter category airplane, regardless of the number of emergency exits. One comment was received and it supports the FAA's proposal. Accordingly, this proposal is adopted as proposed.

*Proposal 4.* Proposed new § 23.812 would require that an emergency lighting system be installed when the applicant for type certification chooses to comply with the alternate emergency exit provisions of proposed § 23.807(d)(4). Proposed § 23.803(b) requires the use of that emergency lighting system during the emergency evacuation demonstration required for commuter category airplanes.

Two comments were received on this proposal. Both commenters suggest that proposed § 23.803(b) be rewritten to eliminate the evacuation demonstration when they comply with § 23.807(d)(4). Both commenters argue that, in their experience, part 25 emergency exit requirements ensure rapid evacuation as long as the airplane is relatively small.

The FAA disagrees. Emergency evacuation demonstrations for passenger-carrying airplanes are consistent with aviation safety. In the absence of showing an ability to evacuate airplanes and the correction of faults in designs and procedures as they are revealed by tests, these demonstrations will result in lives saved. Furthermore, it is not justifiable to exempt an applicant from § 23.803 because the applicant chooses to comply with § 23.807(d)(4), since the applicant that complies with § 23.807(d)(4) has one less emergency exit than the applicant that complies with § 23.807(d)(1). This proposal is adopted as proposed.

*Proposal 5.* This proposal would add requirements for emergency exits that are available to the flightcrew in an emergency landing. These requirements are intended to ensure that the crew has ready access to an emergency exit when their access to the cabin area aft of the cockpit is blocked by cargo constraints or other barriers. Both normal category (single & multiengine) and commuter category airplanes

One commenter supports the proposal to establish a standard minimum for flightcrew emergency exits; however, the commenter believes that the FAA should conduct tests to determine the minimum exit size that would accommodate pilots in both the ninety-fifth and fifth size percentiles.

Tests to determine exit size were conducted prior to the adoption of a Civil Air Regulations (CAR) amendment in 1962; however, the biometric data derived was taken from the general population and not from a population comprised of pilots. The results of the tests were instrumental in the determination of emergency exit and aisle width requirements. The size of the exits has been determined previously and no change was proposed in the notice. This proposal is adopted without change.

*Proposal 6.* This proposal would allow type certification of commuter category airplanes configured with one emergency exit on the side of the cabin opposite the passenger entry door when additional cabin safety features are provided in the airplane design. This proposal states the additional cabin safety features required to comply with the alternative emergency exit provisions. This proposal would move specific requirements for the passenger entry door and associated integral stairs from § 23.807(d)(1) to proposed § 23.785(f). This proposal would move from § 23.807(d)(1) to § 23.807(d)(3) the requirement that each emergency exit that is not a floor-level exit be located over a wing or, if the exit is not less than six feet from the ground, have a means to assist occupants in reaching the ground.

Because there are many airports where takeoffs and landings are conducted over large bodies of water, this proposal includes airworthiness standards for multiengine airplanes that require emergency exits for ditching to be located above the waterline. This proposal would require that the airplane design provide the airplane occupants with a means of exiting the airplane following an emergency landing in water.

Nine comments were received regarding proposed §§ 23.807(d) and 23.807(e). Two commenters state that, according to the preamble to the NPRM, § 23.807(d)(1)(i) is intended to apply to all commuter category airplanes. The commenters further state that this appears inconsistent and impractical when considering a two-place cargo airplane with a cargo barrier immediately aft of the entrance door. The commenters propose to solve this problem by making proposed § 23.807(d)(4)(i) applicable to all commuter category airplanes.

The FAA disagrees. Proposed § 23.807(d)(1) is intended to apply to all commuter category airplanes, but § 23.807(d)(1)(i) is intended to apply only to commuter category airplanes with a total seating capacity of 15 or fewer. Furthermore, the problem of compliance for two-place cargo airplanes is not considered to be a certification problem because there is no special certification for cargo airplanes. The purpose of this rule is to provide alternative emergency exit and cabin safety requirements for commuter category airplanes that are consistent with the airworthiness standards used by small transport airplanes in part 25. This will enable the applicant to choose the requirements of § 23.807(d)(4) instead of § 23.807(d)(1)

Two commenters propose to delete the reference to § 23.803(b) in proposed § 23.807(d)(4)(iii), stating that it is unnecessary. The FAA disagrees. The reference to § 23.803(b) is a necessary part of § 23.807(d)(4)(iii), directing the applicant to the remaining safety requirements of § 23.807(d)(4) that must be met.

One commenter states that multiengine airplanes are required to have emergency exits in accordance with § 23.807(a) and that proposed § 23.807(e) would effectively require two additional exits, even if the § 23.807(a) exit, the main door, or both are above the waterline. The FAA agrees. The intent of the rule is to require that all multiengine airplanes have available exits for emergency egress following an emergency landing in water; therefore, the reference made in the NPRM under § 23.807(e) to § 23.807(b) or (d) is changed to § 23.807(a) or (d). Section 23.807(e)(1) remains unchanged.

One commenter supports the optional exit configuration introduced by § 23.807(d)(4) and states that it is in substantive alignment with part 25.

successful, this rule provides the applicant with the option of reducing the number of emergency exits required. The compensation for this reduction is accomplished by meeting additional cabin safety requirements. The overall effect is an equivalent level of safety between § 23.807(d)(1) and § 23.807(d)(4), and the standardization of alternative cabin safety and emergency exit requirements for small transport airplanes and commuter category airplanes that comply with § 23.807(d)(4). The request for additional airworthiness standards for low flammability interior materials is beyond the scope of this rulemaking.

One commenter recommends increasing the minimum size of the exit in §§ 23.807(d)(4)(i) and (ii), to the size of a type I exit and requiring it to be floor level. The commenter states that this is necessary because it is the only exit besides the main entry door, and it replaces two other type III exits. The commenter further contends that the flow rates for the type III exits, as listed in § 25.807, support the commenter's opinion that the type III exits are slow and cumbersome to use; and with such obstacles as allowed in proposed § 23.807(d)(3), their efficiency will be reduced even more.

The FAA disagrees. A requirement for exits larger than those proposed is outside the scope of the rulemaking for the reasons noted above. Furthermore, by meeting the requirements of the proposed exit size and the other cabin safety requirements of § 23.807(d)(4)(iii), minimum requirements for this alternative to § 23.807(d)(4) have been established. This proposal is adopted with the aforementioned changes.

*Proposal 7.* This proposal would add emergency exit marking requirements applicable when an applicant for type certification chooses to comply with the alternate emergency exit provisions of proposed § 23.807(d)(4). These proposed requirements would result in emergency exits that are easier to locate in adverse conditions and easier to open once located. The proposal includes additional requirements for both internal and external marking of the emergency exits.

One commenter suggests that, even though some additions to the current § 23.811 may be necessary, a full part 25 treatment is not necessarily appropriate for small part 23 commuter airplanes. The commenter recommends that the FAA reconsider this proposal and suggests that a human factor analysis study, determining how people react in commuter size cabins, be completed before any rulemaking activity begins.

The FAA disagrees. Section 23.811(c) provides additional airworthiness requirements for emergency exit markings that would be applicable when certification to the emergency exit provisions of § 23.807(d)(4) is requested. The choice is that of the applicant. Also, the service experience gained by part 25 small transport airplanes, and the experience gained from part 23 commuter category applicants that have been granted exemptions from the emergency exit requirements of § 23.807(d)(1), has proven successful. Accordingly, this alternative is considered suitable for all applicants and further human factor analysis studies are not required.

One commenter states that proposed § 23.811(c) would require exit path markings that would be unnecessary and burdensome and suggests that it would provide no added safety benefit. The FAA disagrees. This section requires a means to assist occupants in locating emergency exits in dense smoke and does not limit these means to floor proximity lighting only. This proposal is adopted as proposed with the exception of minor editorial corrections.

*Proposal 8.* This proposal would add requirements for an emergency lighting system that would apply to an applicant for type certification that chooses to comply with the alternative emergency exit provisions of proposed § 23.807(d)(4). The proposal defines specific minimum requirements for supplying power, arming, and activating the emergency lighting system. The impact activation requirement is consistent with that for emergency locator transmitters. The proposal would also set certain requirements for illumination, function, and the survivability standards of the emergency lighting system. An emergency lighting system that complies with these proposed requirements would aid occupants in locating the emergency exits and exiting after an emergency landing.

further suggests that emergency lighting requirements should be related only to the number of passengers carried. The FAA disagrees. The emergency lighting requirements are not dependent solely on the number of passengers carried, but are a fundamental aspect of improving cabin safety in emergency evacuations.

Another commenter states that § 23.812(f)(2) implies the use of an inertia switch to activate emergency lighting. The commenter adds that the history of these devices has been poor and the commenter is not convinced of their worth. The FAA disagrees. The use of an inertia switch was not implied in the proposal. The FAA is not mandating the use of specific products in this rulemaking action but rather is addressing an airworthiness requirement. How the applicant chooses to comply with that requirement is left entirely to the applicant.

Another commenter strongly favors emergency lighting but believes that requirements should be adapted for small commuter category airplanes. The commenter suggests that the proposed rule is acceptable through § 23.812(g) and adds that § 23.812(h) should be modified to require bright lights at the emergency exits inside the airplane and outside the exits other than floor level doors.

The FAA disagrees. As proposed these requirements are suitable for the small commuter airplanes and are consistent with the requirements for similarly sized small transport category airplanes.

The same commenter suggests that the floor proximity emergency escape path marking is unnecessary and that § 23.812(h)(3) should be deleted.

The FAA disagrees. Floor proximity emergency escape path marking is intended to allow passengers, who have become oriented within the cabin during the period of general overhead illumination, to find their way to exits unassisted after the general overhead illumination becomes obscured. There are many combinations of lights, markers, and signs that might serve this objective, and each must be shown adequate for the particular cabin interior and exit arrangement; therefore, this performance standard is used to allow design flexibility and ensure the necessary safety.

The same commenter adds that the requirements of § 23.812(i) through § 23.812(l), are acceptable; however, general illumination is not necessary, and § 23.812(l)(1) should probably specify 50 percent instead of 75 percent illumination. General illumination requirements are considered to be an essential element in the standards for providing adequate lighting for the airplane occupants to reach, operate, and egress through the entry door or the emergency exits in emergency situations when the normal interior lighting has been rendered inoperative.

This proposed emergency lighting standard was developed with consideration for: emergency lighting standards used for small transport airplanes; additional airworthiness requirements applied to commuter category airplanes when exemptions to the requirements of §§ 23.807(d)(1)(i) or (ii), were granted; and the need to ensure that the ability to egress a commuter category airplane is maintained when the number of emergency exits is fewer than the number required by §§ 23.807(d)(1)(i) or (ii). It is not necessary to require that all lights, except those directly damaged by the fuselage breakup, remain operative after any single vertical separation of the fuselage during a crash landing. The FAA considers the present requirement that permits 25 percent of certain emergency lights, in addition to those directly damaged by the fuselage breakup, to be rendered inoperative (§ 23.812(l)(2)) adequate to accomplish safe evacuation. This proposal is adopted as proposed.

*Proposal 9.* This proposal would add requirements to ensure emergency exit accessibility when an applicant for type certification chooses to comply with the alternative emergency exit provisions of proposed § 23.807(d)(4). Structural failures or yielding of the airframe can occur during an emergency landing or a crash event and may result in one or more emergency exits or the passenger door being rendered unusable. Since the total number of exits available for emergency egress can be fewer with the alternate emergency exit requirements, this proposal defines minimum unobstructed aisle width at the passenger entry door. This proposal would also add other requirements to ensure that any partitions or doorways within the passenger compartment do not hinder occupant access to the exits during an emergency situation.

subjected to the inertia loads resulting from the ultimate static load factors prescribed in § 23.561(b)(2)." Proposed § 23.813(b)(5) is adopted with the change noted above.

Two commenters suggest that proposed § 23.813(b)(2) be deleted because it is not appropriate to small airplanes that do not use cabin attendants. The FAA disagrees. Since not all exits may be operational during an emergency evacuation, the intent of the rule is to ensure minimum unobstructed aisle width and passenger entryways in order to maintain occupant access to exits. The term "assistance," as used in the proposal, does not necessarily mean cabin attendants. This proposal is adopted with the aforementioned changes.

*Proposal 10.* This proposal would require increased aisle widths when an applicant for type certification chooses to comply with the alternative emergency exit provisions of proposed § 23.807(d)(4). The proposed increased aisle width requirements are intended to ensure that the airplane passengers can reach an exit in an emergency situation even though the floor structure has been warped or there are seats or other items protruding into the normal aisle space.

One commenter supports the establishment of 12 inches as the minimum aisle width and is against allowing aisles as narrow as 9 inches in certain cases. The commenter feels that there is never a time when such a narrow aisle is appropriate. The FAA disagrees. Service experience in small transport category airplanes with a passenger seating capacity of 10 or fewer and an aisle width not less than 9 inches has been found satisfactory.

One commenter states that the expanded aisle widths would cause an increase in the fuselage width of most commuter airplanes and that the proposal would, in most cases, negate the use of any alternate emergency exit provisions. The comment does not reveal whether the commenter has considered that variations in seating layout for new designs would accommodate the requirement and the commenter has supplied no data to support this contention.

One commenter states that, with two abreast seating, aisle width requirements do not control passenger flow in an emergency evacuation. The commenter suggests that if the FAA has evidence that aisle width restricts passenger flow when three abreast seating is used, then the proposed § 23.815(b) should be made applicable only to such arrangements. The commenter adds that the FAA should consider that proposed § 23.815(b) would discriminate against airplanes with two abreast seating because the increased aisle width is generally impractical.

The FAA disagrees. The purpose of the increased aisle width is to increase the probability that occupants can reach an exit during an emergency situation, even though seats or other items may be protruding into the normal aisle space. It is recognized that changes in aisle width have little significant effect on evacuation if minimum airworthiness standards for cabin safety and emergency exits are first met. However, part of the intent of this amendment is to establish these minimum alternative requirements for part 23 commuter category airplanes consistent with those for part 25 small transport category airplanes. This proposal is adopted as proposed.

**Final Regulatory Evaluation, Final Regulatory Flexibility Determination, and Trade Impact Assessment**

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) will generate benefits that justify its costs and is not a "significant regulatory action" as defined in the Executive Order; (2) is not "significant" as defined in DOT's Policies and Procedures; (3) will not have a significant impact on a substantial number of small entities; and (4) will not constitute a barrier to international trade. These analyses, available in the docket, are summarized below.

of $325,000 discounted at seven percent to present value.

Historical accident data do not reveal that crewmember fatalities have occurred as a result of inability to exit cargo-laden airplanes in otherwise survivable accidents. However, such an occurrence is a possibility. As applied to the above representative certification, the additional flightcrew exits would be cost-beneficial if only one fatality was prevented. For the purpose of quantifying benefits, the FAA currently uses a minimum value of $2,600,000 to statistically represent a human fatality avoided.

*Emergency Ditching Requirements*

Most current multiengine airplane models would satisfy the ditching requirements of the rule. Future models with side exits above the waterline will experience little or no incremental costs. However, designs with overhead emergency exits in lieu of side exits above the waterline would cost approximately $11,000 per airplane, totalling $1,100,000 (using the same production run and service life assumptions used above). Increased fuel cost resulting from added weight is estimated to be $300 per airplane per year, totalling $750,000. These costs total $1,850,000, or $790,000 discounted.

Historical accident data indicate that between 1975 and 1991, 14 multiengine commuter airplanes experienced an emergency forced landing in water, resulting in 43 fatalities in total. Although there is no evidence that the fatalities occurred solely because the available emergency exits were below the waterline (hence making it difficult if not impossible to exit the airplane), such a situation is a distinct possibility absent the new requirements. As applied to the above type certification, the modified emergency exits would be cost-beneficial if only two fatalities were prevented.

*Remaining Provisions of the Rule*

With the exception of the provisions related to the flightcrew exit and emergency ditching, the rule changes will not result in additional costs to manufacturers. Most of the changes will provide manufacturers of certain commuter category airplanes with a choice of either:

(1) Designing to current part 23 cabin safety standards which require two emergency exits (in addition to the passenger entry door) for airplanes with a total passenger seating capacity of 15 or fewer, or three emergency exits (in addition to the passenger entry door) for airplanes with a total passenger seating capacity of 16 to 19; or

(2) Designing to the alternative part 23 standards that mirror the current requirements for part 25 small transport category airplanes requiring only one exit (in addition to the passenger entry door) for airplanes with a passenger seating capacity of 19 or fewer, and also requiring many other cabin safety improvements that are not currently required for part 23 commuter airplanes.

A manufacturer would choose the alternative that is more cost-effective. A nonquantifiable benefit of this rule is that it will make the cabin safety requirements of commuter category airplanes consistent with those of small transport category airplanes of similar passenger capacities.

**Regulatory Flexibility Determination**

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by government regulations. The RFA requires agencies to review rules which may have "a significant economic impact on a substantial number of small entities."

As defined by implementing FAA Order 2100.14A, the size threshold for designating an aircraft manufacturer a small entity is 75 employees; that is, an aircraft manufacturer with more than 75 employees is not considered to be a small entity. A substantial number of small entities is defined as a number which is not fewer than 11 and which is more than one-third of the small entities subject to the rule. Since there are fewer than 11 small airplane manufacturers that will be affected by the new requirements, the rule will not have a significant economic impact on a substantial number of small entities.

between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this final rule does not have federalism implications to warrant the preparation of a Federalism Assessment.

## Conclusion

This final rule upgrades the emergency egress requirements of the airworthiness standards for normal, utility, acrobatic, and commuter category airplanes. Applicants seeking new type certification for all airplane categories will be required to provide for ditching and flightcrew emergency exits to ensure that emergency exits are available to all flightcrew members and that emergency exits are available to all multiengine airplane occupants during an emergency landing in water. In addition, this final rule provides an applicant seeking type certification for commuter category airplanes the option of meeting exit requirements that are consistent with the existing transport category standards.

For the reasons discussed in the preamble, and based on the findings in the Regulatory Evaluation, the FAA has determined that this regulation is nonsignificant under Executive Order 12866. In addition, the FAA certifies that this regulation will not have a significant economic impact, positive or negative, on a substantial number of small entities. This regulation is not considered significant under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979). A regulatory evaluation of the regulation has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

## The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends part 23 of the Federal Aviation Regulations (14 CFR part 23) effective June 16, 1994.

The authority citation for part 23 continues to read as follows:

*Authority:* 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1425, 1428, 1429, 1430; 49 U.S.C. 106(g).

### § 23.301 Loads.

(a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.

(b) Unless otherwise provided, the air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the airplane. These loads must be distributed to conservatively approximate or closely represent actual conditions. Methods used to determine load intensities and distribution on canard and tandem wing configurations must be validated by flight test measurement unless the methods used for determining those loading conditions are shown to be reliable or conservative on the configuration under consideration.

(c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

(d) Simplified structural design criteria may be used if they result in design loads not less than those prescribed in §§ 23.331 through 23.521. For conventional, single-engine airplanes with design weights of 6,000 pounds or less, the design criteria of appendix A of this part are an approved equivalent of §§ 23.321 through 23.459. If appendix A is used, the entire appendix must be substituted for the corresponding sections of this part.

(Amdt. 23–28, Eff. 4/28/82); (Amdt. 23–42, Eff. 2/4/91)

### 23.302 Canard or tandem wing configurations.

The forward structure of a canard or tandem wing configuration must:

(a) Meet all requirements of subpart C and subpart D of this part applicable to a wing; and

(b) Meet all requirements applicable to the function performed by these surfaces.

Unless otherwise provided, a factor of safety of 1.5 must be used.

### § 23.305 Strength and deformation.

(a) The structure must be able to support limit loads without detrimental, permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.

(b) [The structure must be able to support ultimate loads without failure for at least three seconds, except local failures or structural instabilities between limit and ultimate load are acceptable only if the structure can sustain the required ultimate load for at least three seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the three second limit does not apply.]

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.307 Proof of structure.

(a) Compliance with the strength and deformation requirements of § 23.305 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. Dynamic tests, including structural flight tests, are acceptable if the design load conditions have been simulated.

(b) Certain parts of the structure must be tested as specified in subpart D of this part.

## FLIGHT LOADS

### § 23.321 General.

(a) Flight load factors represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the airplane) to the weight of the airplane. A positive flight load factor is one in which the aerodynamic force acts upward, with respect to the airplane.

(b) Compliance with the flight load requirements of this subpart must be shown—

ibility must be taken into account.]

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.331 Symmetrical flight conditions.

(a) The appropriate balancing horizontal tail load must be accounted for in a rational or conservative manner when determining the wing loads and linear inertia loads corresponding to any of the symmetrical flight conditions specified in §§ 23.333 through 23.341.

(b) The incremental horizontal tail loads due to maneuvering and gusts must be reacted by the angular inertia of the airplane in a rational or conservative manner.

(c) Mutual influence of the aerodynamic surfaces must be taken into account when determining flight loads.

(Amdt. 23–42, Eff. 2/4/91)

### § 23.333 Flight envelope.

(a) *General.* Compliance with the strength requirements of this subpart must be shown at any combination of airspeed and load factor on and within the boundaries of a flight envelope (similar to the one in paragraph (d) of this section) that represents the envelope of the flight loading conditions specified by the maneuvering and gust criteria of paragraphs (b) and (c) of this section respectively.

(b) *Maneuvering envelope.* Except where limited by maximum (static) lift coefficients, the airplane is assumed to be subjected to symmetrical maneuvers resulting in the following limit load factors:

(1) The positive maneuvering load factor specified in § 23.337 at speeds up to $V_D$;

to symmetrical vertical gusts in level flight. The resulting limit load factors must correspond to the conditions determined as follows:

(i) Positive (up) and negative (down) gusts of 50 f.p.s. at $V_C$ must be considered at altitudes between sea level and 20,000 feet. The gust velocity may be reduced linearly from 50 f.p.s. at 20,000 feet to 25 f.p.s. at 50,000 feet.

(ii) Positive and negative gusts of 25 f.p.s. at $V_D$ must be considered at altitudes between sea level and 20,000 feet. The gust velocity may be reduced linearly from 25 f.p.s. at 20,000 feet to 12.5 f.p.s. at 50,000 feet.

(iii) In addition, for commuter category airplanes, positive (up) and negative (down) rough air gusts of 66 f.p.s. at $V_B$ must be considered at altitudes between sea level and 20,000 feet. The gust velocity may be reduced linearly from 66 f.p.s. at 20,000 feet to 38 f.p.s. at 50,000 feet.

(2) The following assumptions must be made:

(i) The shape of the gust is—

$$U=\frac{U_{de}}{2}\left(1-\cos\frac{2\pi s}{25C}\right)$$

where—

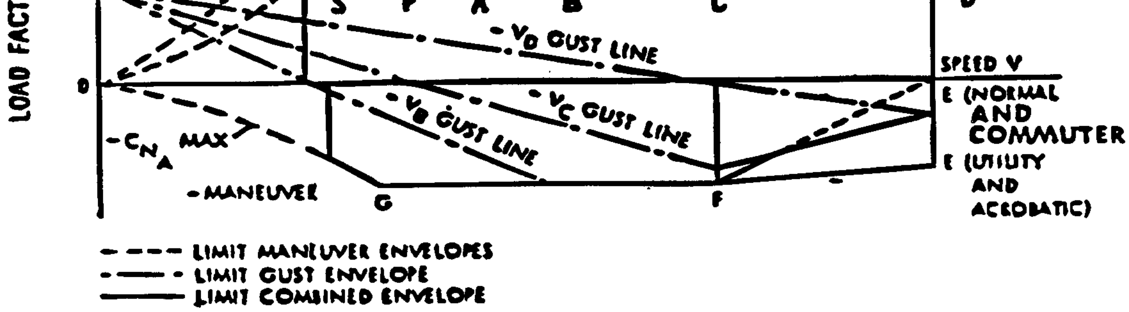
$s$=Distance penetrated into gust (ft.);

$C$=Mean geometric chord of wing (ft.); and

$U_{de}$=Derived gust velocity referred to in subparagraph (1) of this section.

(ii) Gust load factors vary linearly with speed between $V_C$ and $V_D$.

(d) *Flight envelope.*




NOTE: Point G need not be investigated when the supplementary condition specified in § 23.369 is investigated.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

### § 23.335 Design airspeeds.

Except as provided in paragraph (a)(4) of this section, the selected design airspeeds are equivalent airspeeds (EAS).

(a) *Design cruising speed, $V_C$.* For $V_C$ the following apply:

(1) $V_C$ (in knots) may not be less than—

(i) $33\sqrt{W/S}$ (for normal, utility, and commuter category airplanes); and

(ii) $36\sqrt{W/S}$ (For acrobatic category airplanes).

(2) For values of *W/S* more than 20, the multiplying factors may be decreased linearly with *W/S* to a value of 28.6 where *W/S*=100.

(3) $V_C$ need not be more than 0.9 $V_H$ at sea level.

(4) At altitudes where an $M_D$ is established, a cruising speed $M_C$ limited by compressibility may be selected.

(b) *Design dive speed $V_D$.* For $V_D$, the following apply:

(1) $V_D/M_D$ may not be less than 1.25 $V_C/M_C$; and

(2) With $V_{C\ min}$, the required minimum design cruising speed, $V_D$ (in knots) may not be less than—

(i) 1.40 $V_{C\ min}$ (for normal and commuter category airplanes);

(ii) 1.50 $V_{C\ min}$ (for utility category airplanes); and

(iii) 1.55 $V_{C\ min}$ (for acrobatic category airplanes).

(3) For values of *W/S* more than 20, the multiplying factors in paragraph (b)(2) of this section may be decreased linearly with *W/S* to a value of 1.35 where *W/S*=100.

(4) Compliance with paragraphs (b)(1) and (2) of this section need not be shown if $V_D/M_D$ is selected so that the minimum speed margin between $V_C/M_C$ and $V_D/M_D$ is the greater of the following:

(i) The speed increase resulting when, from the initial condition of stabilized flight at $V_C/M_C$, the airplane is assumed to be upset, flown for 20 seconds along a flight path 7.5° below the initial path, and then pulled up with a load factor of 1.5 (0.5g acceleration increment). At least 75 percent maximum continuous power for reciprocating engines, and maximum cruising power for turbines, or, if less, the power required for $V_C/M_C$ for both kinds of engines, must be assumed until the pullup is initiated, at which point power reduction and pilot-controlled drag devices may be used.

(ii) Mach 0.05 (at altitudes where an $M_D$ is established).

(c) *Design maneuvering speed $V_A$.* For $V_A$, the following applies:

(1) $V_A$ may not be less than $V_S \sqrt{n}$ where—

For $V_B$, the following apply:

(1) $V_B$ may not be less than the speed determined by the intersection of the line representing the maximum positive lift $C_{N\ max}$ and the line representing the rough air gust velocity on the gust V–n diagram, or $\sqrt{(N_g)}\ V_{S1}$, whichever is less, where:

(i) $n_g$ the positive airplane gust load factor due to gust, at speed $V_C$ (in accordance with § 23.341), and at the particular weight under consideration; and

(ii) $V_{S1}$ is the stalling speed with the flaps retracted at the particular weight under consideration.

(2) $V_B$ need not be greater than $V_C$.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–16, Eff. 2/14/75); (Amdt. 23–34, Eff. 2/17/87)

### § 23.337 Limit maneuvering load factors.

(a) The positive limit maneuvering load factor $n$ may not be less than—

(1) 2.1 + [24,000/($W$ + 10,000)] for normal and commuter category airplanes, except that $n$ need not be more than 3.8;

(2) 4.4 for utility category airplanes; or

(3) 6.0 for acrobatic category airplanes.

(b) The negative limit maneuvering load factor may not be less than—

(1) 0.4 times the positive load factor for the normal, utility, and commuter categories; or

(2) 0.5 times the positive load factor for the acrobatic category.

(c) Maneuvering load factors lower than those specified in this section may be used if the airplane has design features that make it impossible to exceed these values in flight.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

### § 23.341 Gust load factors.

(a) The gust load for a canard or tandem wing configuration must be computed using a rational analysis, considering the criteria of § 23.333(c), to

$$n=1+\frac{K_g U_{de} V a}{498(W/S)}$$

where—

$$K_g=\frac{0.88\ \mu_g}{5.3+\mu_g} = \text{gust alleviation factor;}$$

$$\mu_g=\frac{2(w/s)}{\rho C a g} = \text{airplane mass ratio;}$$

$U_{de}$ = Derived gust velocities referred to in § 23.333(c) (f.p.s.);
$\rho$ = Density of air (slugs/cu. ft.);
$W/S$ = Wing loading (p.s.f.);
$C$ = Mean geometric chord (ft.);
$g$ = Acceleration due to gravity (ft/sec.$^2$);
$V$ = Airplane equivalent speed (knots); and
$a$ = Slope of the airplane normal force coefficient curve $C_{NA}$ per radian if the gust loads are applied to the wings and horizontal tail surfaces simultaneously by a rational method. The wing lift curve slope $C_L$ per radian may be used when the gust load is applied to the wings only and the horizontal tail gust loads are treated as a separate condition.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

### § 23.345 High lift devices.

(a) If flaps or similar high lift devices to be used for takeoff, approach, or landing are installed, the airplane, with the flaps fully deflected at $V_F$, is assumed to be subjected to symmetrical maneuvers and gusts resulting in limit load factors within the range determined by—

(1) Maneuvering, to a positive limit load factor of 2.0; and

(2) Positive and negative gust of 25 feet per second acting normal to the flight path in level flight.

(b) $V_F$ must be assumed to be not less than 1.4 $V_S$ or 1.8 $V_{SF}$, whichever is greater,

where—

$V_S$ is the computed stalling speed with flaps retracted at the design weight; and
$V_{SF}$ is the computed stalling speed with flaps fully extended at the design weight.

§ 23.457(b).

(d) In determining external loads on the airplane as a whole, thrust, slipstream, and pitching acceleration may be assumed to be zero.

(e) The requirements of § 23.457, and this section may be complied with separately or in combination.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–23, Eff. 12/1/78)

### § 23.347 Unsymmetrical flight conditions.

The airplane is assumed to be subjected to the unsymmetrical flight conditions of §§ 23.349 and 23.351. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner, considering the principal masses furnishing the reacting inertia forces.

### § 23.349 Rolling conditions.

The wing and wing bracing must be designed for the following loading conditions:

(a) Unsymmetrical wing loads appropriate to the category. Unless the following values result in unrealistic loads, the rolling accelerations may be obtained by modifying the symmetrical flight conditions in § 23.333(d) as follows:

(1) For the acrobatic category, in conditions A and F, assume that 100 percent of the semispan wing airload acts on one side of the plane of symmetry and 60 percent of this load acts on the other side.

(2) For the normal, utility, and commuter categories, in condition A, assume that 100 percent of the semispan wing airload acts on one side of the airplane, and 70 percent of this load acts on the other side. For airplanes of more than 1,000 pounds design weight, the latter percentage may be increased linearly with weight up through 75 percent at 12,500 pounds to the maximum gross weight of the airplane.

(b) The loads resulting from the aileron deflections and speeds specified in § 23.455, in combination with an airplane load factor of at least two thirds of the positive maneuvering load factor used for design. Unless the following values result in

$\Delta c_m$ is the moment coefficient increment; and

$\delta$ is the down aileron deflection in degrees in the critical condition.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

### § 23.351 Yawing conditions.

The airplane must be designed for yawing loads on the vertical surfaces resulting from the loads specified in §§ 23.441 through 23.445.

(Amdt. 23–42, Eff. 2/4/91)

### § 23.361 Engine torque.

(a) Each engine mount and its supporting structure must be designed for the effects of—

(1) A limit engine torque corresponding to takeoff power and propeller speed acting simultaneously with 75 percent of the limit loads from flight condition A of § 23.333(d);

(2) [A limit engine torque corresponding to maximum continuous power and propeller speed acting simultaneously with the limit loads from flight condition A of § 23.333(d); and]

(3) For turbopropeller installations, in addition to the conditions specified in paragraphs (a)(1) and (a)(2) of this section, a limit engine torque corresponding to takeoff power and propeller speed, multiplied by a factor accounting for propeller control system malfunction, including quick feathering, acting simultaneously with lg level flight loads. In the absence of a rational analysis, a factor of 1.6 must be used.

(b) For turbine engine installations, the engine mounts and supporting structure must be designed to withstand each of the following:

(1) A limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).

(2) A limit engine torque load imposed by the maximum acceleration of the engine.

(c) [The limit engine torque to be considered under paragraph (a) of this section must be obtained by multiplying the mean torque by a factor of—]

(1) 1.25 for turbopropeller installations;

(a) Each engine mount and its supporting structure must be designed for a limit load factor in a lateral direction, for the side load on the engine mount, of not less than—

(1) 1.33; or

(2) One-third of the limit load factor for flight condition A.

(b) The side load prescribed in paragraph (a) of this section may be assumed to be independent of other flight conditions.

### § 23.365 Pressurized cabin loads.

For each pressurized compartment, the following apply:

(a) The airplane structure must be strong enough to withstand the flight loads combined with pressure differential loads from zero up to the maximum relief valve setting.

(b) The external pressure distribution in flight, and any stress concentrations, must be accounted for.

(c) If landings may be made with the cabin pressurized, landing loads must be combined with pressure differential loads from zero up to the maximum allowed during landing.

(d) The airplane structure must be strong enough to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33, omitting other loads.

(e) If a pressurized cabin has two or more compartments separated by bulkheads or a floor, the primary structure must be designed for the effects of sudden release of pressure in any compartment with external doors or windows. This condition must be investigated for the effects of failure of the largest opening in the compartment. The effects of intercompartmental venting may be considered.

### § 23.367 Unsymmetricai loads due to engine failure.

(a) Turbopropeller airplanes must be designed for the unsymmetrical loads resulting from the failure of the critical engine including the following conditi- compressor from the turbine or from loss of the turbine blades are considered to be ultimate loads.

(3) The time history of the thrust decay and drag buildup occurring as a result of the prescribed engine failures must be substantiated by test or other data applicable to the particular engine-propeller combination.

(4) The timing and magnitude of the probable pilot corrective action must be conservatively estimated, considering the characteristics of the particular engine-propeller-airplane combination.

(b) Pilot corrective action may be assumed to be initiated at the time maximum yawing velocity is reached, but not earlier than 2 seconds after the engine failure. The magnitude of the corrective action may be based on the limit pilot forces specified in § 23.397 except that lower forces may be assumed where it is shown by analysis or test that these forces can control the yaw and roll resulting from the prescribed engine failure conditions.

(Amdt. 23–7, Eff. 9/14/69)

### § 23.369 [Rear lift truss.]

(a) If a rear lift truss is used, it must be designed for conditions of reversed airflow at a design speed of—

$$V = 8.7\sqrt{W/S} + 8.7 \text{ (knots)}$$

(b) Either aerodynamic data for the particular wing section used, or a value of $C_L$ equalling –0.8 with a chordwise distribution that is triangular between a peak at the trailing edge and zero at the leading edge, must be used.

(Amdt. 23–7, Eff. 9/14/69); [(Amdt. 23–45, Eff. 9/7/93)]

### § 23.371 [Gyroscopic and aerodynamic loads.

[For turbine-powered airplanes, each engine mount and its supporting structure must be designed for the combined gyroscopic and aerodynamic loads that result, with the engines at maximum continuous r.p.m., under either of the following conditions:]

(a) The conditions prescribed in §§ 23.351 and 23.423.

## § 23.373 Speed control devices.

If speed control devices (such as spoilers and drag flaps) are incorporated for use in enroute conditions—

(a) The airplane must be designed for the symmetrical maneuvers and gusts prescribed in §§ 23.333, 23.337, and 23.341, and the yawing maneuvers and lateral gusts in §§ 23.441 and 23.443, with the device extended at speeds up to the placard device extended speed; and

(b) If the device has automatic operating or load limiting features, the airplane must be designed for the maneuver and gust conditions prescribed in paragraph (a) of this section at the speeds and corresponding device positions that the mechanism allows.

(Amdt. 23–7, Eff. 9/14/69)

# CONTROL SURFACE AND SYSTEM LOADS

## § 23.391 Control surface loads.

(a) The control surface loads specified in §§ 23.397 through 23.459 are assumed to occur in the conditions described in §§ 23.331 through 23.351.

(b) If allowed by the following sections, the values of control surface loading in appendix B of this part may be used, instead of particular control surface data, to determine the detailed rational requirements of §§ 23.397 through 23.459, unless these values result in unrealistic loads.

## § 23.395 Control system loads.

(a) Each flight control system and its supporting structure must be designed for loads corresponding to at least 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in §§ 23.391 through 23.459. In addition, the following apply:

(1) The system limit loads need not exceed the higher of the loads that can be produced by the pilot and automatic devices operating the controls. However, autopilot forces need not be

(2) The design must, in any case, provide a rugged system for service use, considering jamming, ground gusts, taxiing downwind, control inertia, and friction. Compliance with this subparagraph may be shown by designing for loads resulting from application of the minimum forces prescribed in § 23.397(b).

(b) A 125 percent factor on computed hinge moments must be used to design elevator, aileron, and rudder systems. However, a factor as low as 1.0 may be used if hinge moments are based on accurate flight test data, the exact reduction depending upon the accuracy and reliability of the data.

(c) Pilot forces used for design are assumed to act at the appropriate control grips or pads as they would in flight, and to react at the attachments of the control system to the control surface horns.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

## § 23.397 Limit control forces and torques.

(a) In the control surface flight loading condition, the airloads on movable surfaces and the corresponding deflections need not exceed those that would result in flight from the application of any pilot force within the ranges specified in paragraph (b) of this section. In applying this criterion, the effects of control system boost and servo-mechanisms, and the effects of tabs must be considered. The automatic pilot effort must be used for design if it alone can produce higher control surface loads than the human pilot.

(b) The limit pilot forces and torques are as follows:

| Control | Maximum forces to torques for design weight, weight equal to or less than 5,000 pounds [1] | Minimum forces or torques [2] |
|---|---|---|
| Aileron: | | |
| Stick | 67 lbs. | 40 lbs. |
| Wheel [3] | 50 D in. lbs.[4] | 40 D in. lbs.[4] |
| Elevator: | | |
| Stick | 167 lbs. | 100 lbs. |

| | | |
|---|---|---|
| Rudder | 200 lbs. | [150] lbs. |

[1] For design weight ($W$) more than 5,000 pounds, the specified maximum values must be increased linearly with weight to 1.18 times the specified values at a design weight of 12,500 pounds, and for commuter category airplanes, the specified values must be increased linearly with weight to 1.35 times the specified values at a design weight of 19,000 pounds.

[2] If the design of any individual set of control systems or surfaces makes these specified minimum forces or torques inapplicable, values corresponding to the present hinge moments obtained under § 23.415, but not less than 0.6 of the specified minimum forces or torques, may be used.

[3] The critical parts of the aileron control system must also be designed for a single tangential force with a limit value of 1.25 times the couple force determined from the above criteria.

[4] D = wheel diameter (inches).

[5] The unsymmetrical force must be applied at one of the normal handgrip points on the control wheel.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–17, Eff. 2/1/77); (Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

### § 23.399 Dual control system.

Each dual control system must be designed for the pilots operating in opposition, using individual pilot forces not less than—

(a) 0.75 times those obtained under § 23.395; or

(b) The minimum forces specified in § 23.397(b).

### § 23.405 Secondary control system.

Secondary controls, such as wheel brakes, spoilers, and tab controls, must be designed for the maximum forces that a pilot is likely to apply to those controls.

### § 23.407 Trim tab effects.

The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by maximum pilot effort. In these cases, the tabs are considered to be deflected in the direction that would assist the pilot. These deflections must correspond to the maximum degree of ''out of trim'' expected at the speed for the condition under consideration.

follows for control surface loads due to ground gusts and taxiing downwind:

(1) If an investigation of the control system for ground gust loads is not required by subparagraph (2) of this paragraph, but the applicant elects to design a part of the control system for these loads, these loads need only be carried from control surface horns through the nearest stops or gust locks and their supporting structures.

(2) If pilot forces less than the minimums specified in § 23.397(b) are used for design, the effects of surface loads due to ground gusts and taxiing downwind must be investigated for the entire control system according to the formula:

$H = KcSq$

where—

$H$ = limit hinge moment (ft.-lbs.);

$c$ = mean chord of the control surface aft of the hinge line (ft.);

$S$ = area of control surface aft of the hinge line (sq. ft.);

$q$ = dynamic pressure (p.s.f) based on a design speed not less than $14.6 \sqrt{W/S} + 14.6$ (f.p.s.) except that the design speed need not exceed 88 (f.p.s.); and

$K$ = limit hinge moment factor for ground gusts derived in paragraph (b) of this section. (For ailerons and elevators, a positive value of $K$ indicates a moment tending to depress the surface and a negative value of $K$ indicates a moment tending to raise the surface).

(b) The limit hinge moment factor $K$ for ground gusts must be derived as follows:

| Surface | K | Position of controls |
|---|---|---|
| (a) Aileron | 0.75 | Control column locked or lashed in mid-position. |
| (b) Aileron | ±0.50 | Ailerons at full throw; + moment on one aileron, – moment on the other. |
| (c) Elevator | ±0.75 | (c) Elevator full up (–). |
| (d) Elevator | .............. | (d) Elevator full down (+). |
| (e) Rudder | ±0.75 | (e) Rudder in neutral. |
| (f) Rudder | .............. | (f) Rudder at full throw. |

[(c) The tie-down attachment fittings and the surrounding structure must be designed for limit load conditions resulting from wind speeds up to

### § 23.421 Balancing loads.

(a) A horizontal surface balancing load is a load necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.

(b) Horizontal balancing surfaces must be designed for the balancing loads occurring at any point on the limit maneuvering envelope and in the flap conditions specified in § 23.345.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

### § 23.423 Maneuvering loads.

Each horizontal surface and its supporting structure, and the main wing of a canard or tandem wing configuration, if that surface has pitch control, must be designed for the maneuvering loads imposed by the following conditions:

(a) A sudden movement of the pitching control, at the speed $V_A$, to the maximum aft movement, and the maximum forward movement, as limited by the control stops, or pilot effort, whichever is critical.

(b) A sudden aft movement of the pitching control at speeds above $V_A$, followed by a forward movement of the pitching control resulting in the following combinations of normal and angular acceleration:

| Condition | Normal acceleration ($n$) | Angular acceleration (radian/sec$_2$) |
|---|---|---|
| Nose-up pitching. | 1.0 | $+39n_m/V \times (n_m - 1.5)$ |
| Nose-down pitching. | $n_m$ | $-39n_m/V \times (n_m - 1.5)$ |

where—

$n_m$ = positive limit maneuvering load factor used in the design of the airplane; and

V = initial speed in knots.

The conditions in this paragraph involve loads corresponding to the loads that may occur in a ''checked maneuver'' (a maneuver in which the pitching control is suddenly displaced in one direction and then suddenly moved in the opposite direction). The deflections and timing of the ''checked

### § 23.425 Gust loads.

(a) Each horizontal surface, other than a main wing, must be designed for loads resulting from—

(1) Gust velocities specified in § 23.333(c) with flaps retracted; and

(2) Positive and negative gusts of 25 f.p.s. nominal intensity at $V_F$ corresponding to the flight conditions specified in § 23.345(a)(2).

(b) Reserved

(c) When determining the total load on the horizontal surfaces for the conditions specified in paragraph (a) of this section, the initial balancing loads for-steady unaccelerated flight at the pertinent design speeds $V_F$, $V_C$, and $V_D$ must first be determined. The incremental load resulting from the gusts must be added to the initial balancing load to obtain the total load.

(d) In the absence of a more rational analysis, the incremental load due to the gust must be computed as follows only on airplane configurations with aft-mounted, horizontal surfaces, unless its use elsewhere is shown to be conservative:

$$\Delta L_{ht} = \frac{K_g U_{de} V a_{ht} S_{ht}}{498}\left(1-\frac{d\varepsilon}{d\alpha}\right)$$

where—

$\Delta L_{ht}$ = Incremental horizontal tail load (lbs.);

$K_g$ = Gust alleviation factor defined in § 23.341;

$U_{de}$ = Derived gust velocity (f.p.s.);

$V$ = Airplane equivalent speed (knots);

$a_{ht}$ = Slope of aft horizontal tail lift curve (per radian);

$S_{ht}$ = Area of aft horizontal lift surface (ft$^2$); and

$\left(1-\frac{d\varepsilon}{d\alpha}\right)$ = Downwash factor.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

### § 23.427 Unsymmetrical loads.

(a) Horizontal surfaces other than main wing and their supporting structure must be designed for the symmetrical flight conditions may be assumed on the surface on one side of the plane of symmetry; and

(2) The following percentage of that loading must be applied to the opposite side:

Percent = 100−10 ($n$−1), where $n$ is the specified positive maneuvering load factor, but this value may not be more than 80 percent.

(c) For airplanes that are not conventional (such as airplanes with horizontal surfaces other than main wing having appreciable dihedral or supported by the vertical tail surfaces) the surfaces and supporting structures must be designed for combined vertical and horizontal surface loads resulting from each prescribed flight condition taken separately.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–42, Eff. 2/4/91)

## VERTICAL SURFACES

### § 23.441 Maneuvering loads.

(a) At speeds up to $V_A$, the vertical surfaces must be designed to withstand the following conditions. In computing the loads, the yawing velocity may be assumed to be zero:

(1) With the airplane in unaccelerated flight at zero yaw, it is assumed that the rudder control is suddenly displaced to the maximum deflection, as limited by the control stops or by limit pilot forces.

(2) With the rudder deflected as specified in paragraph (a)(1) of this section, it is assumed that the airplane yaws to the resulting sideslip angle. In lieu of a rational analysis, an overswing angle equal to 1.3 times the static sideslip angle of paragraph (a)(3) of this section may be assumed.

(3) A yaw angle of 15° with the rudder control maintained in the neutral position (except as limited by pilot strength).

(b) [Reserved]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–28, Eff. 4/28/82); (Amdt. 23–42, Eff. 2/4/91)

### § 23.443 Gust loads.

(a) Vertical surfaces must be designed to withstand, in unaccelerated flight at speed $V_C$, lateral gusts of the values prescribed for $V_C$ in § 23.333(c).

(b) In addition, for commuter category airplanes, the airplane is assumed to encounter derived gusts normal to the plane of symmetry while in unaccelerated flight at $V_B$, $V_C$, $V_D$, and $V_F$. The derived gusts and airplane speeds corresponding to these conditions, as determined by §§ 23.341 and 23.345, must be investigated. The shape of the gust must be as specified in § 23.333(c)(2)(i).

(c) In the absence of a more rational analysis, the gust load must be computed as follows:

$$L_{vt} = \frac{K_{gt}\, U_{de}\, Va_{vt}\, S_{vt}}{498}$$

where—

$L_{vt}$ = Vertical surface loads (lbs.);

$$K_{gt} = \frac{0.88\,\mu gt}{5.3 + \mu gt} \text{ = gust alleviation factor;}$$

$$\mu gt = \frac{2W}{\rho C_t g a_{vt} S_{vt}} \left( \frac{K}{1_t} \right)^2 \text{ = Lateral mass ratio;}$$

$U_{de}$ = Derived gust velocity (f.p.s);
$\rho$ = Air density (slugs/cu ft.);
$W$ = Airplane weight (lbs.);
$S_{vt}$ = Area of vertical surface (ft.$^2$);
$C_t$ = Mean geometric chord of vertical surface (ft.);
$a_{vt}$ = Lift curve slope of vertical surface (per radian);
$K$ = Radius of gyration in yaw (ft.);
$1_t$ = Distance from airplane c.g. to lift center of vertical surface (ft.);
$g$ = Acceleration due to gravity (ft./sec.$^2$) ; and
$V$ = Airplane equivalent speed (knots).

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–42, Eff. 2/4/91)

and below the horizontal surface, the critical vertical surface loading (the load per unit area as determined under §§ 23.441 and 23.443) must be applied to—

(1) The part of the vertical surfaces above the horizontal surface with 80 percent of that loading applied to the part below the horizontal surface; and

(2) The part of the vertical surfaces below the horizontal surface with 80 percent of that loading applied to the part below the horizontal surface;

(c) The end plate effects of outboard fins or winglets must be taken into account in applying the yawing conditions of § 23.441 and § 23.443 to the vertical surfaces in paragraph (b) of this section.

(d) When rational methods are used for computing loads, the maneuvering loads of § 23.441 on the vertical surfaces and the 1.0g horizontal surface load, including induced loads on the horizontal surface and moments or forces exerted on the horizontal surfaces by the vertical surfaces, must be applied simultaneously for the structural loading condition.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–42, Eff. 2/4/91)

## AILERONS, WING FLAPS, AND SPECIAL DEVICES

### § 23.455 Ailerons.

(a) The ailerons must be designed for the loads to which they are subjected—

(1) In the neutral position during symmetrical flight conditions; and

(2) By the following deflections (except as limited by pilot effort), during unsymmetrical flight conditions; and

(i) Sudden maximum displacement of the aileron control at $V_A$. Suitable allowance may be made for control system deflections.

(ii) Sufficient deflection at $V_C$, where $V_C$ is more than $V_A$, to produce a rate of roll not less than obtained in paragraph (a)(2)(i) of this section.

(a) The wing flaps, their operating mechanisms, and their supporting structures must be designed for critical loads occurring in the flaps-extended flight conditions with the flaps in any position. However, if an automatic flap load limiting device is used, these components may be designed for the critical combinations of airspeed and flap position allowed by that device.

(b) The effects of propeller slipstream, corresponding to takeoff power, must be taken into account at not less than 1.4 $V_S$, where $V_S$ is the computed stalling speed with flaps fully retracted at the design weight. For the investigation of slipstream effects, the load factor may be assumed to be 1.0.

### § 23.459 Special devices.

The loading for special devices using aerodynamic surfaces (such as slots and spoilers) must be determined from test data.

## GROUND LOADS

### § 23.471 General.

The limit ground loads specified in this subpart are considered to be external loads and inertia forces that act upon an airplane structure. In each specified ground load condition, the external reactions must be placed in equilibrium with the linear and angular inertia forces in a rational or conservative manner.

### § 23.473 Ground load conditions and assumptions.

(a) The ground load requirements of this subpart must be complied with at the design maximum weight except that §§ 23.479, 23.481, and 23.483 may be complied with at a design landing weight (the highest weight for landing conditions at the maximum descent velocity) allowed under paragraphs (b) and (c) of this section.

(b) The design landing weight may be as low as—

(c) The design landing weight of a multiengine airplane may be less than that allowed under paragraph (b) of this section if—

(1) The airplane meets the one-engine-inoperative climb requirements of § 23.67(a) or (b)(1); and

(2) Compliance is shown with the fuel jettisoning system requirements of § 23.1001.

(d) The selected limit vertical inertia load factor at the center of gravity of the airplane for the ground load conditions prescribed in this subpart may not be less than that which would be obtained when landing with a descent velocity (V), in feet per second, equal to 4.4 $(W/S)^{1/4}$ except that this velocity need not be more than 10 feet per second and may not be less than seven feet per second.

(e) Wing lift not exceeding two-thirds of the weight of the airplane may be assumed to exist throughout the landing impact and to act through the center of gravity. The ground reaction load factor may be equal to the inertia load factor minus the ratio of the above assumed wing lift to the airplane weight.

(f) [Energy absorption tests (to determine the limit load factor corresponding to the required limit descent velocities) must be made under § 23.723(a) unless specifically exempted by that section.]

(g) No inertia load factor used for design purposes may be less than 2.67, nor may the limit ground reaction load factor be less than 2.0 at design maximum weight, unless these lower values will not be exceeded in taxiing at speeds up to takeoff speed over terrain as rough as that expected in service.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–28, Eff. 4/28/82); [(Amdt. 23–45, Eff. 9/7/93)]

### § 23.477 Landing gear arrangement.

Sections 23.479 through 23.483, or the conditions in appendix C, apply to airplanes with conventional arrangements of main and nose gear, or main and tail gear.

ground simultaneously; and

(ii) The main wheels contact the ground and the nose wheel is just clear of the ground.

The attitude used in paragraph (a)(2)(i) of this section may be used in the analysis required under paragraph (a)(2)(ii) of this section.

(b) [When investigating landing conditions, the drag components simulating the forces required to accelerate the tires and wheels up to the landing speed (spin-up) must be properly combined with the corresponding instantaneous vertical ground reactions, and the forward-acting horizontal loads resulting from rapid reduction of the spin-up drag loads (spring-back) must be combined with vertical ground reactions at the instant of the peak forward load, assuming wing lift and a tire-sliding coefficient of friction of 0.8. However, the drag loads may not be less than 25 percent of the maximum vertical ground reactions (neglecting wing lift).

(c) [In the absence of specific tests or a more rational analysis for determining the wheel spin-up and spring-back loads for landing conditions, the method set forth in appendix D of this part must be used. If appendix D of this part is used, the drag components used for design must not be less than those given by appendix C of this part.]

(d) For airplanes with tip tanks or large overhung masses (such as turbo-propeller or jet engines) supported by the wing, the tip tanks and the structure supporting the tanks or overhung masses must be designed for the effects of dynamic responses under the level landing conditions of either paragraph (a)(1) or (a)(2)(ii) of this section. In evaluating the effects of dynamic, response, an airplane lift equal to the weight of the airplane may be assumed.

(Amdt. 23–17, Eff. 2/1/77); [(Amdt. 23–45, Eff. 9/7/93)]

### § 23.481 Tail down landing conditions.

(a) For a tail down landing, the airplane is assumed to be in the following attitudes:

the wheels up to speed before the maximum vertical load is attained.

### § 23.483 One-wheel landing conditions.

For the one-wheel landing condition, the airplane is assumed to be in the level attitude and to contact the ground on one side of the main landing gear. In this attitude, the ground reactions must be the same as those obtained on that side under § 23.479.

### § 23.485 Side load conditions.

(a) For the side load condition, the airplane is assumed to be in a level attitude with only the main wheels contacting the ground and with the shock absorbers and tires in their static positions.

(b) The limit vertical load factor must be 1.33, with the vertical ground reaction divided equally between the main wheels.

(c) The limit side inertia factor must be 0.83, with the side ground reaction divided between the main wheels so that—

(1) 0.5 (*W*) is acting inboard on one side; and

(2) 0.33 (*W*) is acting outboard on the other side.

[(d) The side loads prescribed in paragraph (c) of this section are assumed to be applied at the ground contact point and the drag loads may be assumed to be zero.]

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.493 Braked roll conditions.

Under braked roll conditions, with the shock absorbers and tires in their static positions, the following apply:

(a) The limit vertical load factor must be 1.33.

(b) The attitudes and ground contacts must be those described in § 23.479 for level landings.

(c) A drag reaction equal to the vertical reaction at the wheel multiplied by a coefficient of friction of 0.8 must be applied at the ground contact point of each wheel with brakes, except that the drag

(a) For the obstruction load, the limit ground reaction obtained in the tail down landing condition is assumed to act up and aft through the axle at 45°, The shock absorber and tire may be assumed to be in their static positions.

(b) For the side load, a limit vertical ground reaction equal to the static load on the tail wheel, in combination with a side component of equal magnitude, is assumed. In addition—

(1) If a swivel is used, the tail wheel is assumed to be swiveled 90° to the airplane longitudinal axis with the resultant ground load passing through the axle;

(2) If a lock, steering device, or shimmy damper is used, the tail wheel is also assumed to be in the trailing position with the side load acting at the ground contact point; and

(3) The shock absorber and tire are assumed to be in their static positions.

### § 23.499 Supplementary conditions for nose wheels.

In determining the ground loads on nose wheels and affected supporting structures, and assuming that the shock absorbers and tires are in their static positions, the following conditions must be met:

(a) For aft loads, the limit force components at the axle must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A drag component of 0.8 times the vertical load.

(b) For forward loads, the limit force components at the axle must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A forward component of 0.4 times the vertical load.

(c) For side loads, the limit force components at ground contact must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A side component of 0.7 times the vertical load.

(Amdt. 23–7, Eff. 9/14/69)

### § 23.507 Jacking loads.

(a) The airplane must be designed for the loads developed when the aircraft is supported on jacks at the design maximum weight assuming the following load factors for landing gear jacking points at a three-point attitude and for primary flight structure jacking points in the level attitude:

(1) Vertical-load factor of 1.35 times the static reactions.

(2) Fore, aft, and lateral load factors of 0.4 times the vertical static reactions.

(b) The horizontal loads at the jack points must be reacted by inertia forces so as to result in no change in the direction of the resultant loads at the jack points.

(c) The horizontal loads must be considered in all combinations with the vertical load.

(Amdt. 23–14, Eff. 12/20/73)

### § 23.509 Towing loads.

The towing loads of this section must be applied to the design of tow fittings and their immediate attaching structure.

(b) For towing points not on the landing gear but near the plane of symmetry of the airplane, the drag and side tow load components specified for the auxiliary gear apply. For towing points located outboard of the main gear, the drag and side tow load components specified for the main gear apply. Where the specified angle of swivel cannot be reached, the maximum obtainable angle must be used.

(c) The towing loads specified in paragraph (d) of this section must be reacted as follows:

(1) The side component of the towing load at the main gear must be reacted by a side force at the static ground line of the wheel to which the load is applied.

(2) The towing loads at the auxiliary gear and the drag components of the towing loads at the main gear must be reacted as follows:

(i) A reaction with a maximum value equal to the vertical reaction must be applied at the axle of the wheel to which the load is applied. Enough airplane inertia to achieve equilibrium must be applied.

(ii) The loads must be reacted by airplane inertia.

(d) The prescribed towing loads are as follows, where *W* is the design maximum weight:

| Tow point | Position | Load | | |
|---|---|---|---|---|
| | | Magnitude | No. | Direction |
| Main Gear | | 0.225W | 1 | Forward, parallel to drag axis. |
| | | | 2 | Forward, at 30° to drag axis. |
| | | | 3 | Aft, parallel to drag axis. |
| | | | 4 | Aft, at 30° to drag axis. |
| Auxiliary gear | Swiveled forward | 0.3W | 5 | Forward. |
| | | | 6 | Aft. |
| | Swiveled aft | 0.3W | 7 | Forward. |
| | | | 8 | Aft. |
| | Swiveled 45° from forward | 0.15W | 9 | Forward, in plane of wheel. |
| | | | 10 | Aft, in plane of wheel. |
| | Swiveled 45° from aft | 0.15W | 11 | Forward, in plane of wheel. |
| | | | 12 | Aft, in plane of wheel. |

factor of 1, and coefficient of friction of 0.8 applied to the main gear and its supporting structure.

(b) *Unequal tire loads.* The loads established under §§ 23.471 through 23.483 must be applied in turn, in a 60/40 percent distribution, to the dual wheels and tires in each dual wheel landing gear unit.

(c) *Deflated tire loads.* For the deflated tire condition—

(1) 60 percent of the loads established under §§ 23.471 through 23.483 must be applied in turn to each wheel in a landing gear unit; and

(2) 60 percent of the limit drag and side loads, and 100 percent of the limit vertical load established under §§ 23.485 and 23.493 or lesser vertical load obtained under paragraph (c)(1) of this section, must be applied in turn to each wheel in the dual wheel landing gear unit.

(Amdt. 23–7, Eff. 9/14/69)

## WATER LOADS

### § 23.521 Water load conditions.

(a) The structure of seaplanes and amphibians must be designed for water loads developed during takeoff and landing with the seaplane in any attitude likely to occur in normal operation at appropriate forward and sinking velocities under the most severe sea conditions likely to be encountered.

(b) [Unless the applicant makes a rational analysis of the water loads, §§ 23.523 through 23.537 apply.

(c) [Floats previously approved by the FAA may be installed on airplanes that are certificated under this part, provided that the floats meet the criteria of paragraph (a) of this section.]

[(Amdt. 23–45, Eff. 9/7/93)]

### [§ 23.523 Design weights and center of gravity positions.

(a) *Design weights.* The water load requirements must be met at each operating weight up to the

[(Amdt. 23–45, Eff. 9/7/93)]

### [§ 23.525 Application of loads.

[(a) Unless otherwise prescribed, the seaplane as a whole is assumed to be subjected to the loads corresponding to the load factors specified in § 23.527.

(b) In applying the loads resulting from the load factors prescribed in § 23.527, the loads may be distributed over the hull or main float bottom (in order to avoid excessive local shear loads and bending moments at the location of water load application) using pressures not less than those prescribed in § 23.533(c).

(c) For twin float seaplanes, each float must be treated as an equivalent hull on a fictitious seaplane with a weight equal to one-half the weight of the twin float seaplane.

(d) Except in the takeoff condition of § 23.531, the aerodynamic lift on the seaplane during the impact is assumed to be ⅔ of the weight of the seaplane.]

[(Amdt. 23–45, Eff. 9/7/93)]

### [§ 23.527 Hull and main float load factors.

[(a) Water reaction load factors $n_w$ must be computed in the following manner:

(1) For the step landing case

$$n_w = \frac{C_1 V_{SO}^2}{(\mathrm{Tan}^{2/3}\beta)\, W^{1/3}}$$

(2) For the bow and stern landing cases

$$n_w = \frac{C_1 V_{SO}^2}{(\mathrm{Tan}^{2/3}\beta)\, W^{1/3}} \times \frac{K_1}{(1+r_x^2)^{2/3}}$$

(b) The following values are used:

(1) $n_w$ = water reaction load factor (that is, the water reaction divided by seaplane weight).

(2) $C_1$ = empirical seaplane operations factor equal to 0.012 (except that this factor may not

(5) W = seaplane design landing weight in pounds.

(6) $K_1$ = empirical hull station weighing factor, in accordance with figure 2 of appendix I of this part.

(7) $r_x$ = ratio of distance, measured parallel to hull reference axis, from the center of gravity of the seaplane to the hull longitudinal station at which the load factor is being computed to the radius of gyration in pitch of the seaplane, the hull reference axis being a straight line, in the plane of symmetry, tangential to the keel at the main step.

(c) For a twin float seaplane, because of the effect of flexibility of the attachment of the floats to the seaplane, the factor $K_1$ may be reduced at the bow and stern to 0.8 of the value shown in figure 2 of appendix I of this part. This reduction applies only to the design of the carrythrough and seaplane structure.]

[(Amdt. 23–45, Eff. 9/7/93)]

### [§ 23.529 Hull and main float landing conditions.

[(a) *Symmetrical step, bow, and stern landing.* For symmetrical step, bow, and stern landings, the limit water reaction load factors are those computed under § 23.527. In addition—

(1) For symmetrical step landings, the resultant water load must be applied at the keel, through the center of gravity, and must be directed perpendicularly to the keel line;

(2) For symmetrical bow landings, the resultant water load must be applied at the keel, one-fifth of the longitudinal distance from the bow to the step, and must be directed perpendicularly to the keel line; and

(3) For symmetrical stern landings, the resultant water load must be applied at the keel, at a point 85 percent of the longitudinal distance from the step to the stern post, and must be directed perpendicularly to the keel line.

(b) *Unsymmetrical landing for hull and single float seaplanes.* Unsymmetrical step, bow, and stern as that in the symmetrical condition, and the point of application of the side component is at the same longitudinal station as the upward component but is directed inward perpendicularly to the plane of symmetry at a point midway between the keel and the chine lines.

(c) *Unsymmetrical landing; twin float seaplanes.* The unsymmetrical loading consists of an upward load at the step of each float of 0.75 and a side load of 0.25 tan β at one float times the step landing load reached under § 23.527. The side load is directed inboard, perpendicularly to the plane of symmetry midway between the keel and chine lines of the float, at the same longitudinal station as the upward load.]

[(Amdt. 23–45, Eff. 9/7/93)]

### [§ 23.531 Hull and main float takeoff condition.

[For the wing and its attachment to the hull or main float—

(a) The aerodynamic wing lift is assumed to be zero; and

(b) A downward inertia load, corresponding to a load factor computed from the following formula, must be applied:

$$n = \frac{C_{TO} V_{S1}{}^2}{(\tan^{2/3}\beta) W^{1/3}}$$

where—

n = inertia load factor;

$C_{TO}$ = empirical seaplane operations factor equal to 0.004;

$V_{S1}$ = seaplane stalling speed (knots) at the design takeoff weight with the flaps extended in the appropriate takeoff position;

β = angle of dead rise at the main step (degrees); and

W = design water takeoff weight in pounds.]

[(Amdt. 23–45, Eff. 9/7/93)]

### [§ 23.533 Hull and main float bottom pressures.

[(a) *General.* The hull and main float structure, including frames and bulkheads, stringers, and bottom plating, must be designed under this section.

(p.s.i.) is computed as follows:

$$P_k = \frac{C_2 K_2 V_{S1}^2}{\text{Tan } \beta_k}$$

where—

$P_k$ = pressure (p.s.i.) at the keel;

$C_2$ = 0.00213;

$K_2$ = hull station weighing factor, in accordance with figure 2 of appendix I of this part;

$V_{S1}$ = seaplane stalling speed (knots) at the design water takeoff weight with flaps extended in the appropriate takeoff position; and

$\beta_K$ = angle of dead rise at keel, in accordance with figure 1 of appendix I of this part.

(2) For a flared bottom, the pressure at the beginning of the flare is the same as that for an unflared bottom, and the pressure between the chine and the beginning of the flare varies linearly, in accordance with figure 3 of appendix I of this part. The pressure distribution is the same as that prescribed in paragraph (b)(1) of this section for an unflared bottom except that the pressure at the chine is computed as follows:

$$P_{ch} = \frac{C_3 K_2 V_{S1}^2}{\text{Tan } \beta}$$

where—

$P_{ch}$ = pressure (p.s.i.) at the chine;

$C_3$ = 0.0016;

$K_2$ = hull station weighing factor, in accordance with figure 2 of appendix I of this part;

$V_{S1}$ = seaplane stalling speed (knots) at the design water takeoff weight with flaps extended in the appropriate takeoff position; and

$\beta$ = angle of dead rise at appropriate station.

The area over which these pressures are applied must simulate pressures occuring during high localized impacts on the hull or float, but need not extend over an area that would induce critical stresses in the frames or in the overall structure.

(c) *Distributed pressures.* For the design of the frames, keel, and chine structure, the following pressure distributions apply:

(1) Symmetrical pressures as computed as follows—

in the appropriate position and with no slipstream effect; and

$\beta$ = angle of dead rise at appropriate station.

(2) The unsymmetrical pressure distribution consists of the pressures prescribed in paragraph (c)(1) of this section on one side of the hull or main float centerline and one-half of that pressure on the other side of the hull or main float centerline, in accordance with figure 3 of appendix I of this part.

(3) These pressures are uniform and must be applied simultaneously over the entire hull or main float bottom. The loads obtained must be carried into the sidewall structure of the hull proper, but need not be transmitted in a fore and aft direction as shear and bending loads.]

[(Amdt. 23–45, Eff. 9/7/93)]

### [§ 23.535 Auxiliary float loads.

[(a) *General.* Auxiliary floats and their attachments and supporting structures must be designed for the conditions prescribed in this section. In the cases specified in paragraphs (b) through (e) of this section, the prescribed water loads may be distributed over the float bottom to avoid excessive local loads, using bottom pressures not less than those prescribed in paragraph (g) of this section.

(b) *Step loading.* The resultant water load must be applied in the plane of symmetry of the float at a point three-fourths of the distance from the bow to the step and must be perpendicular to the keel. The resultant limit load is computed as follows, except that the value of L need not exceed three times the weight of the displaced water when the float is completely submerged:

$$L = \frac{C_5 V_{S0}^2 W^{2/3}}{\text{Tan}^{2/3} \beta_s (1 + r_y^2)^{2/3}}$$

where—

L = limit load (lbs.);

$C_5$ = 0.0053;

$V_{S0}$ = seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect;

W = seaplane design landing weight in pounds;

to the keel line at that point. The magnitude of the resultant load is that specified in paragraph (b) of this section.

(d) *Unsymmetrical step loading.* The resultant water load consists of a component equal to 0.75 times the load specified in paragraph (a) of this section and a side component equal to 0.25 tan $\beta$ times the load specified in paragraph (b) of this section. The side load must be applied perpendicularly to the plane of symmetry of the float at a point midway between the keel and the chine.

(e) *Unsymmetrical bow loading.* The resultant water load consists of a component equal to 0.75 times the load specified in paragraph (b) of this section and a side component equal to 0.25 tan $\beta$ times the load specified in paragraph (c) of this section. The side load must be applied perpendicularly to the plane of symmetry at a point midway between the keel and the chine.

(f) *Immersed float condition.* The resultant load must be applied at the centroid of the cross section of the float at a point one-third of the distance from the bow to the step. The limit load components are as follows:

$$\text{vertical} = \rho g V;$$

$$\text{aft} = \frac{C_X \rho \, V^{2/3} \, (K \, V_{SO})^2}{2};$$

$$\text{side} = \frac{C_Y \rho \, V^{2/3} \, (K \, V_{SO})^2}{2};$$

where—

$\rho$ = mass density of water (slugs/ft.$^3$);

$V$ = volume of float (ft.$^3$);

$C_X$ = coefficient of drag force, equal to 0.133;

$C_Y$ = coefficient of side force, equal to 0.106;

$K$ = 0.8, except that lower values may be used if it is shown that the floats are incapable of submerging at a speed of 0.8 $V_{SO}$ in normal operations;

$V_{SO}$ = seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect; and

$g$ = acceleration due to gravity (ft/sec$^2$).

[Seawing design loads must be based on applicable test data.]

[(Amdt. 23–45, Eff. 9/7/93)]

## EMERGENCY LANDING CONDITIONS

### § 23.561 General.

(a) The airplane, although it may be damaged in emergency landing conditions, must be designed as prescribed in this section to protect each occupant under those conditions.

(b) The structure must be designed to protect each occupant during emergency landing conditions when—

(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design;

(2) The occupant experiences the static inertia loads corresponding to the following ultimate load factors—

(i) Upward, 3.0g for normal, utility, and commuter category airplanes, or 4.5g for acrobatic category airplanes;

(ii) Forward, 9.0g;

(iii) Sideward, 1.5g; and

[(iv) Downward, 6.0g when certification to the emergency exit provisions of § 23.807(d)(4) is requested; and]

(3) The items of mass within the cabin, that could injure an occupant, experience the static inertia loads corresponding to the following ultimate load factors—

(i) Upward, 3.0g;

(ii) Forward, 18.0g; and

(iii) Sideward, 4.5g.

(c) Each airplane with retractable landing gear must be designed to protect each occupant in a landing—

(1) With the wheels retracted;

(2) With moderate descent velocity; and

(3) Assuming, in the absence of a more rational analysis—

by an analysis assuming the following conditions—

(i) Maximum weight;

(ii) Most forward center of gravity position;

(iii) Longitudinal load factor of 9.0g;

(iv) Vertical load factor of 1.0g; and

(v) For airplanes with tricycle landing gear, the nose wheel strut failed with the nose contacting the ground.

(2) For determining the loads to be applied to the inverted airplane after a turnover, an upward ultimate inertia load factor of 3.0g and a coefficient of friction with the ground of 0.5 must be used.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–36, Eff. 9/14/88); [(Amdt. 23–46, Eff. 6/16/94)]

### § 23.562 Emergency landing dynamic conditions.

(a) Each seat/restraint system for use in a normal, utility, or acrobatic category airplane must be designed to protect each occupant during an emergency landing when—

(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for the design; and

(2) The occupant is exposed to the loads resulting from the conditions prescribed in this section.

(b) [Except for those seat/restraint systems that are required to meet paragraph (d) of this section, each seat/restraint system for crew or passenger occupancy in a normal, utility, or acrobatic category airplane, must successfully complete dynamic tests or be demonstrated by rational analysis supported by dynamic tests, in accordance with each of the following conditions.] These tests must be conducted with an occupant simulated by an anthropomorphic test dummy (ATD) defined by 49 CFR part 572, subpart B, or an FAA-approved equivalent, with a nominal weight of 170 pounds and seated in the normal upright position.

(1) For the first test, the change in velocity may not be less than 31 feet per second. The seat/restraint system must be oriented in its nomi-

and must reach a minimum of 15g.

(2) For the second test, the change in velocity may not be less than 42 per second. The seat/restraint system must be oriented in its nominal position with respect to the airplane and with the vertical plane of the airplane yawed 10°, with no pitch, relative to the impact vector in a direction that results in the greatest load on the shoulder harness. For seat/restraint systems to be installed in the first row of the airplane, peak deceleration must occur in not more than 0.05 seconds after impact and must reach a minimum of 26g. For all other seat/restraint systems, peak deceleration must occur in not more than 0.06 seconds after impact and must reach and minimum of 21g.

(3) To account for floor warpage, the floor rails of attachment devices used to attach the seat/restraint system to the airframe structure must be preloaded to misalign with respect to each other by at least 10° vertically (i.e., pitch out of parallel) and one of the rails or attachment devices must be preloaded to misalign by 10 degrees in roll prior to conducting the test defined by paragraph (b)(2) of this section.

(c) Compliance with the following requirements must be shown during the dynamic tests conducted in accordance with paragraph (b) of this section:

(1) The seat/restraint system must restrain the ATD although seat/restraint system components may experience deformation, elongation, displacement, or crushing intended as part of the design.

(2) The attachment between the seat/restraint system and the test fixture must remain intact, although the seat structure may have deformed.

(3) Each shoulder harness strap must remain on the ATD's shoulder during the impact.

(4) The safety belt must remain on the ATD's pelvis during the impact.

(5) The results of the dynamic tests must show that the occupant is protected from serious head injury.

(i) When contact with adjacent seats, structure, or other items in the cabin can occur, protection must be provided so that head the final integration time, expressed in seconds, ($t_2-t_1$) is the time duration of the major head impact, expressed in seconds, and a(t) is the resultant deceleration at the center of gravity of the head form expressed as a multiple of g (units of gravity).

(iii) Compliance with the HIC limit must be demonstrated by measuring the head impact during dynamic testing as prescribed in paragraphs (b)(1) and (b)(2) of this section or by a separate showing of compliance with the head injury criteria using test or analysis procedures.

(6) Loads in individual shoulder harness straps may not exceed 1,750 pounds. If dual straps are used for retaining the upper torso, the total strap loads may not exceed 2,000 pounds.

(7) The compression load measured between the pelvis and the lumbar spine of the ATD may not exceed 1,500 pounds.

[(d) For all single-engine airplanes with a $V_{SO}$ of more than 61 knots at maximum weight, and those multiengine airplanes of 6,000 pounds or less maximum weight with a $V_{SO}$ of more than 61 knots at maximum weight that do not comply with § 23.67(b)(2)(i):

[(1) The ultimate load factors of § 23.561(b) must be increased by multiplying the load factors by the square of the ratio of the increased stall speed to 61 knots. The increased ultimate load factors need not exceed the values reached at a $V_{SO}$ of 79 knots. The upward ultimate load factor for acrobatic category airplanes need not exceed 5.0g.

[(2) The seat/restraint system test required by paragraph (b)(1) of this section must be conducted in accordance with the following criteria:

[(i) The change in velocity may not be less than 31 feet per second.

[(ii)(A) The peak deceleration ($g_p$) of 19g and 15g must be increased and multiplied by the square of the ratio of the increased stall speed to 61 knots:

$$g_p = 19.0\,(V_{SO}/61)^2 \text{ or } g_p = 15.0\,(V_{SO}/61)^2$$

where—

$g_p$ = The peak deceleration calculated in accordance with paragraph (d)(2)(ii) of this section; and

$t_r$ = The rise time (in seconds) to the peak deceleration.]

([e]) An alternate approach that achieves an equivalent, or greater, level of occupant protection to that required by this section may be used if substantiated on a rational basis.

(Amdt. 23–36, Eff. 9/14/88); [(Amdt. 23–44, Eff. 8/18/93)]

## FATIGUE EVALUATION

### § 23.571 Pressurized cabin.

The strength, detail design, and fabrication of the pressure cabin structure must be evaluated under [one] of the following:

(a) A fatigue strength investigation, in which the structure is shown by analysis, tests, or both to be able to withstand the repeated loads of variable magnitude expected in service. Analysis alone is considered acceptable only when it is conservative and applied to simple structures.

(b) A fail safe strength investigation, in which it is shown by analysis, tests, or both that catastrophic failure of the structure is not probable after fatigue failure, or obvious partial failure, of a principal structural element, and that the remaining structures are able to withstand a static ultimate load factor of 75 percent of the limit load factor at $V_C$, considering the combined effects of normal operating pressures, expected external aerodynamic pressures, and flight loads. These loads must be multiplied by a factor of 1.15 unless the dynamic effect of failure under static load are otherwise considered.

[(c) The damage tolerance evaluation of § 23.573(b).]

(Amdt. 23–14, Eff. 12/20/73); [(Amdt. 23–45, Eff. 9/7/93)] expected uses are comparable, from a fatigue standpoint, to a similar design that has had extensive satisfactory service experience:

(1) A fatigue strength investigation in which the structure is shown by analysis, tests, or both to be able to withstand the repeated loads of variable magnitude expected in service. Analysis alone is acceptable only when it is conservative and applied to simple structures; or

(2) A fail safe strength investigation in which it is shown by analysis, tests, or both, that catastrophic failure of the structure is not probable after fatigue failure, or obvious partial failure, of a principal structural element, and that the remaining structure is able to withstand a static ultimate load factor of 75 percent of the critical limit load at $V_C$. These loads must be multiplied by a factor of 1.15 unless the dynamic effects of failure under static load are otherwise considered.

**[**(3) The damage tolerance evaluation of § 23.573(b).**]**

(b) Each evaluation required by this section must—

(1) Include typical loading spectra (e.g., taxi, ground-air-ground cycles, maneuver, gust);

(2) Account for any significant effects due to the mutual influence of aerodynamic surfaces; and

(3) Consider any significant effects from propeller slipstream loading, and buffet from vortex impingements.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–38, Eff. 10/26/89); **[**(Amdt. 23–45, Eff. 9/7/93)**]**

### [§ 23.573 Damage tolerance and fatigue evaluation of structure.

**[**(a) *Composite airframe structure.* Composite airframe structure must be evaluated under this paragraph instead of §§ 23.571 and 23.572. The applicant must evaluate the composite airframe structure, the failure of which would result in catastrophic loss of the airplane, in each wing (includ-

tion. Where bonded joints are used, the structure must also be evaluated in accordance with paragraph (a)(5) of this section. The effects of material variability and environmental conditions on the strength and durability properties of the composite materials must be accounted for in the evaluations required by this section.

(1) It must be demonstrated by tests, or by analysis supported by tests, that the structure is capable of carrying ultimate load with damage up to the threshold of detectability considering the inspection procedures employed.

(2) The growth rate or no-growth of damage that may occur from fatigue, corrosion, manufacturing flaws or impact damage, under repeated loads expected in service, must be established by tests or analysis supported by tests.

(3) The structure must be shown by residual strength tests, or analysis supported by residual strength tests, to be able to withstand critical limit flight loads, considered as ultimate loads, with the extent of detectable damage consistent with the results of the damage tolerance evaluations. For pressurized cabins, the following loads must be withstood:

(i) Critical limit flight loads with the combined effects of normal operating pressure and expected external aerodynamic pressures.

(ii) The expected external aerodynamic pressures in 1g flight combined with a cabin differential pressure equal to 1.1 times the normal operating differential pressure without any other load.

(4) The damage growth, between initial detectability and the value selected for residual strength demonstrations, factored to obtain inspection intervals, must allow development of an inspection program suitable for application by operation and maintenance personnel.

(5) The limit load capacity of each bonded joint must be substantiated by one of the following methods:

(i) The maximum disbonds of each bonded joint consistent with the capability to withstand the loads in paragraph (a)(3) of this section ensure the strength of each joint.

(6) Structural components for which the damage tolerance method is shown to be impractical must be shown by component fatigue tests, or analysis supported by tests, to be able to withstand the repeated loads of variable magnitude expected in service. Sufficient component, subcomponent, element, or coupon tests must be done to establish the fatigue scatter factor and the environmental effects. Damage up to the threshold of detectability and ultimate load residual strength capability must be considered in the demonstration.

(b) *Metallic airframe structure.* If the applicant elects to use § 23.571(c) or § 23.572(a)(3), then the damage tolerance evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. The determination must be by analysis supported by test evidence and, if available, service experience. Damage at multiple sites due to fatigue structure is able to withstand critical limit flight loads, considered as ultimate, with the extent of dectectable damage consistent with the results of the damage tolerance evaluations. For pressurizing cabins, the following load must be withstood:

(1) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in this part, and

(2) The expected external aerodynamic pressures in 1g flight combined with a cabin differential pressure equal to 1.1 times the normal operating differential pressure without any other load.

(c) *Inspection.* Based on evaluations required by this section, inspections or other procedures must be established as necessary to prevent catastrophic failure and must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 23.1529.]

[(Amdt. 23–45, Eff. 9/7/93)]

The suitability of each questionable design detail and part having an important bearing on safety in operations, must be established by tests.

### § 23.603 Materials and workmanship.

(a) The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must—

(1) Be established by experience or tests;

(2) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and

(3) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

(b) Workmanship must be of a high standard.

(Amdt. 23–17, Eff. 2/1/77); (Amdt. 23–23, Eff. 12/1/78)

### § 23.605 Fabrication methods.

(a) The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to reach this objective, the process must be performed under an approved process specification.

(b) Each new aircraft fabrication method must be substantiated by a test program.

(Amdt. 23–23, Eff. 12/1/78)

### § 23.607 Self-locking nuts.

No self-locking nut may be used on any bolt subject to rotation in operation unless a non friction locking device is used in addition to the self-locking device.

(Amdt. 23–17, Eff. 2/1/77)

### § 23.609 Protection of structure.

Each part of the structure must—

(a) Be suitably protected against deterioration or loss of strength in service due to any cause, including—

(2) Corrosion; and

(3) Abrasion; and

(b) Have adequate provisions for ventilation and drainage.

### § 23.611 Accessibility.

Means must be provided to allow inspection (including inspection of principal structural elements and control systems), close examination, repair, and replacement of each part requiring maintenance, adjustments for proper alignment and function, lubrication or servicing.

(Amdt. 23–7, Eff. 9/14/69)

### § 23.613 Material strength properties and design values.

(a) Material strength properties must be based on enough tests of material meeting specifications to establish design values on a statistical basis.

(b) [Design values must be chosen to minimize the probability of structural failure due to material variability. Except as provided in paragraph (e) of this section, compliance with this paragraph must be shown by selecting design values that ensure material strength with the following probability:

(1) Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in loss of structural integrity of the component; 99 percent probability with 95 percent confidence.

(2) For redundant structure, in which the failure of individual elements would result in applied loads being safely distributed to other load carrying members; 90 percent probability with 95 percent confidence.]

(c) [The effects of temperature on allowable stresses used for design in an essential component or structure must be considered where thermal effects are significant under normal operating conditions.

[(d) The design of the structure must minimize the probability of catastrophic fatigue failure, particularly at points of stress concentration.

9/7/93)]

### § 23.615 Design properties. [Removed]

(Amdt. 23–7, Eff. 9/14/69); [(Amdt. 23–45, Eff. 9/7/93)]

### § 23.619 Special factors.

The factor of safety prescribed in § 23.303 must be multiplied by the highest pertinent special factors of safety prescribed in §§ 23.621 through 23.625 for each part of the structure whose strength is—

(1) Uncertain;

(2) Likely to deteriorate in service before normal replacement; or

(3) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

(Amdt. 23–7, Eff. 9/14/69)

### § 23.621 Casting factors.

(a) *General.* The factors, tests, and inspections specified in paragraphs (b) through (d) of this section must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Paragraphs (c) and (d) of this section apply to any structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.

(b) *Bearing stresses and surfaces.* The casting factors specified in paragraphs (c) and (d) of this section—

(1) Need not exceed 1.25 with respect to bearing stresses regardless of the method of inspection used; and

(2) Need not be used with respect to the bearing surfaces of a part whose bearing factor is larger than the applicable casting factor.

(c) *Critical castings.* For each casting whose failure would preclude continued safe flight and landing of the airplane or result in serious injury to occupants, the following apply:

(1) [Each critical casting must either—

procedure is established and an acceptable statistical analysis supports reduction, nondestructive inspection may be reduced from 100 percent, and applied on a sampling basis.]

(2) For each critical casting with a casting factor less than 1.50, three sample castings must be static tested and shown to meet—

(i) The strength requirements of § 23.305 at an ultimate load corresponding to a casting factor of 1.25; and

(ii) The deformation requirements of § 23.305 at a load of 1.15 times the limit load.

(3) Examples of these castings are structural attachment fittings, parts of flight control systems, control surface hinges and balance weight attachments, seat, berth, safety belt, and fuel and oil tank supports and attachments, and cabin pressure valves.

(d) *Non-critical castings.* For each casting other than those specified in paragraph (c) [or (e)] of this section, the following apply:

(1) Except as provided in paragraphs (d)(2) and (3) of this section, the casting factors and corresponding inspections must meet the following table:

| Casting factor | Inspection |
|---|---|
| 2.0 or more ........... | 100 percent visual. |
| Less than 2.0 but more than 1.5. | 100 percent visual, and magnetic particle or penetrant or equivalent nondestructive inspection methods. |
| 1.25 through 1.50. | 100 percent visual, magnetic particle or penetrant, and radiographic, or approved equivalent nondestructive inspection methods. |

(2) The percentage of castings inspected by nonvisual methods may be reduced below that specified in paragraph (d)(1) of this section when an approved quality control procedure is established.

(3) For castings procured to a specification that guarantees the mechanical properties of the material in the casting and provides for dem-

non-structural purposes do not require evaluation, testing or close inspection.]

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.623 Bearing factors.

(a) Each part that has clearance (free fit), and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion.

(b) For control surface hinges and control system joints, compliance with the factors prescribed in §§ 23.657 and 23.693, respectively, meets paragraph (a) of this section.

(Amdt. 23–7, Eff. 9/14/69)

### § 23.625 Fitting factors.

For each fitting (a part or terminal used to join one structural member to another), the following apply:

(a) For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of at least 1.15 must be applied to each part of—

(1) The fitting;

(2) The means of attachment; and

(3) The bearing on the joined members.

(b) No fitting factor need be used for joint designs based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood).

(c) For each integral fitting, the part must be treated as a fitting up to the point at which the section properties become typical of the member.

(d) For each seat, berth, safety belt, and harness, its attachment to the structure must be shown, by analysis, tests, or both, to be able to withstand the inertia forces prescribed in § 23.561 multiplied by a fitting factor of 1.33.

(Amdt. 23–7, Eff. 9/14/69)

specified in paragraph (b), (c), or (d) of this section, or a combination of these methods, that the airplane is free from flutter, control reversal, and divergence for any condition of operation within the limit V–*n* envelope, and at all speeds up to the speed specified for the selected method. In addition—

(1) Adequate tolerances must be established for quantities which affect flutter; including speed, damping, mass balance, and control system stiffness; and

(2) The natural frequencies of main structural components must be determined by vibration tests or other approved methods.

(b) A rational analysis may be used to show that the airplane is free from flutter, control reversal, and divergence if the analysis shows freedom from flutter for all speeds up to 1.2 $V_D$.

(c) Flight flutter tests may be used to show that the airplane is free from flutter, control reversal, and divergence if it is shown by these tests that—

(1) Proper and adequate attempts to induce flutter have been made within the speed range up to $V_D$;

(2) The vibratory response of the structure during the test indicates freedom from flutter;

(3) A proper margin of damping exists at $V_D$; and

(4) There is no large and rapid reduction in damping as $V_D$ is approached.

(d) Compliance with the rigidity and mass balance criteria (pages 4–12), in Airframe and Equipment Engineering Report No. 45 (as corrected) "Simplified Flutter Prevention Criteria" (published by the Federal Aviation Administration) may be accomplished to show that the airplane is free from flutter, control reversal, or divergence if—

(1) [$V_D/M_D$ for the airplane is less than 260 knots (EAS) and less than Mach 0.5,]

(2) The wing and aileron flutter prevention criteria, as represented by the wing torsional stiffness and aileron balance criteria, are limited in use to airplanes without large mass concentrations (such as engines, floats, or fuel tanks in outer wing panels) along the wing span, and

(3) The airplane—

into account the stability of the plane of rotation of the propeller and significant elastic, inertial, and aerodynamic forces, and

(2) Propeller, engine, engine mount, and airplane structure stiffness and damping variations appropriate to the particular configuration.

(f) Freedom from flutter, control reversal, and divergence up to $V_D/M_D$ must be shown as follows:

(1) For airplanes that meet the criteria of paragraphs (d)(1) through (3) of this section, after the failure, malfunction, or disconnection of any single element in any tab control system.

(2) For airplanes other than those described in paragraph (f)(1) of this section, after the failure, malfunction, or disconnection of any single element in the primary flight control system, any tab control system, or any flutter damper.

[(g) For airplanes showing compliance with the fail-safe criteria of §§ 23.571 and 23.572, the airplane must be shown by analysis or test to be free from flutter to $V_D/M_D$ after fatigue failure, or obvious partial failure of a principal structural element.

[(h) For airplanes showing compliance with the damage-tolerance criteria of § 23.573, the airplane must be shown by analysis or test to be free from flutter to $V_D/M_D$ with the extent of damage for which residual strength is demonstrated.]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–23, Eff. 12/1/78); (Amdt. 23–31, Eff. 12/28/84); [(Amdt. 23–45, Eff. 9/7/93)]

## WINGS

### § 23.641 Proof of strength.

The strength of stressed-skin wings must be proven by load tests or by combined structural analysis and load tests.

### § 23.655 Installation.

(a) [Movable surfaces must be installed so that there is no interference between any surfaces, their bracing, or adjacent fixed structure, when one surface is held in its most critical clearance positions and the others are operated through their full movement.]

(b) If an adjustable stabilizer is used, must have stops that will limit its range of travel to that allowing safe flight and landing.

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.657 Hinges.

(a) Control surface hinges, except ball and roller bearing hinges, must have a factor of safety of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing.

(b) For ball or roller bearing hinges, the approved rating of the bearing may not be exceeded.

(c) Hinges must have enough strength and rigidity for loads parallel to the hinge line.

### § 23.659 Mass balance.

The supporting structure and the attachment of concentrated mass balance weights used on control surfaces must be designed for—

(a) 24g normal to the plane of the control surface;

(b) 12g fore and aft; and

(c) 12g parallel to the hinge line.

## CONTROL SYSTEMS

### § 23.671 General.

(a) Each control must operate easily, smoothly, and positively enough to allow proper performance of its functions.

(b) Controls must be arranged and identified to provide for convenience in operation and to prevent comply with § 23.671 and the following:

(a) A warning, which is clearly distinguishable to the pilot under expected flight conditions without requiring the pilot's attention, must be provided for any failure in the stability augmentation system or in any other automatic or power-operated system that could result in an unsafe condition if the pilot was not aware of the failure. Warning systems must not activate the control system.

(b) The design of the stability augmentation system or of any other automatic or power-operated system must permit initial counteraction of failures without requiring exceptional pilot skill or strength, by either the deactivation of the system or a failed portion thereof, or by overriding the failure by movement of the flight controls in the normal sense.

(c) It must be shown that, after any single failure of the stability augmentation system or any other automatic or power-operated system—

(1) The airplane is safely controllable when the failure or malfunction occurs at any speed or altitude within the approved operating limitations that is critical for the type of failure being considered;

(2) The controllability and maneuverability requirements of this part are met within a practical operational flight envelope (for example, speed, altitude, normal acceleration, and airplane configuration) that is described in the Airplane Flight Manual (AFM); and

(3) The trim, stability, and stall characteristics are not impaired below a level needed to permit continued safe flight and landing.]

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.673 Primary flight controls.

(a) Primary flight controls are those used by the pilot for the immediate control of pitch, roll, and yaw.

(b) The design of two-control airplanes must minimize the likelihood of complete loss of lateral or directional control in the event of failure of any connecting or transmitting element in the control system.

(c) Each step must be able to withstand any loads corresponding to the design conditions for the control system.

(Amdt. 23–17, Eff. 2/1/77)

### § 23.677 Trim systems.

(a) Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim tab operation. There must be means near the trim control to indicate to the pilot the direction of trim control movement relative to airplane motion. In addition, there must be means to indicate to the pilot the position of the trim device with respect to the range of adjustment. This means must be visible to the pilot and must be located and designed to prevent confusion.

(b) Trimming devices must be designed so that, when any one connecting or transmitting element in the primary flight control system fails, adequate control for safe flight and landing is available with—

(1) For single-engine airplanes, the longitudinal trimming devices; or

(2) For multiengine airplanes, the longitudinal and directional trimming devices.

(c) Tab controls must be irreversible unless the tab is properly balanced and has no unsafe flutter characteristics. Irreversible tab systems must have adequate rigidity, and reliability in the portion of the system from the tab to the attachment of the irreversible unit to the airplane structure.

(d) It must be demonstrated that the airplane is safely controllable and that the pilot can perform all maneuvers and operations necessary to effect a safe landing following any probable powered trim system runaway that reasonably might be expected in service, allowing for appropriate time delay after pilot recognition of the trim system runaway. The demonstration must be conducted at critical airplane weights and center of gravity positions.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–42, Eff. 2/4/91)

a normal manner.

(b) The device must be installed to limit the operation of the airplane so that, when the device is engaged, the pilot receives unmistakable warning at the start of takeoff.

(c) The device must have a means to preclude the possibility of it becoming inadvertently engaged in flight.]

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.681 Limit load static tests.

(a) Compliance with the limit load requirements of this part must be shown by tests in which—

(1) The direction of the test loads produces the most severe loading in the control system; and

(2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included.

(b) Compliance must be shown (by analyses or individual load tests) with the special factor requirements for control system joints subject to angular motion.

### § 23.683 Operation tests.

(a) It must be shown by operation tests that, when the controls are operated from the pilot compartment with the system loaded as prescribed in paragraph (b) of this section, the system is free from—

(1) Jamming;

(2) Excessive friction; and

(3) Excessive deflection.

(b) The prescribed test loads are—

(1) For the entire system, loads corresponding to the limit airloads on the appropriate surface, or the limit pilot forces in § 23.397(b), whichever are less; and

(2) For secondary controls, loads not less than those corresponding to the maximum pilot effort established under § 23.405.

(Amdt. 23–7, Eff. 9/14/69)

of cables or tubes against other parts.

(d) Each element of the flight control system must have design features, or must be distinctively and permanently marked, to minimize the possibility of incorrect assembly that could result in malfunctioning of the control system.

(Amdt. 23–17, Eff. 2/1/77)

### § 23.687 Spring devices.

The reliability of any spring device used in the control system must be established by tests simulating service conditions unless failure of the spring will not cause flutter or unsafe flight characteristics.

### § 23.689 Cable systems.

(a) Each cable, cable fitting, turnbuckle, splice, and pulley used must meet approved specifications. In addition—

(1) No cable smaller than ⅛ inch diameter may be used in primary control systems;

(2) Each cable system must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations; and

(3) There must be means for visual inspection at each fairlead, pulley, terminal, and turnbuckle.

(b) Each kind and size of pulley must correspond to the cable with which it is used. Each pulley must have closely fitted guards to prevent the cables from being misplaced or fouled, even when slack. Each pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange.

(c) Fairleads must be installed so that they do not cause a change in cable direction of more than 3°.

(d) Clevis pins subject to load or motion and retained only by cotter pins may not be used in the control system.

(e) Turnbuckles must be attached to parts having angular motion in a manner that will positively prevent binding throughout the range of travel.

are subject to angular motion, except those in ball and roller bearing systems, must have a special factor of safety of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for joints in cable control systems. For ball or roller bearings, the approved ratings may not be exceeded.

### § 23.697 Wing flap controls.

(a) Each wing flap control must be designed so that, when the flap has been placed in any position upon which compliance with the performance requirements of this part is based, the flap will not move from that position unless the control is adjusted or is moved by the automatic operation of a flap load limiting device.

(b) The rate of movement of the flaps in response to the operation of the pilot's control or automatic device must give satisfactory flight and performance characteristics under steady or changing conditions of airspeed, engine power, and attitude.

### § 23.699 Wing flap position indicator.

There must be a wing flap position indicator for—

(a) Flap installations with only the retracted and fully extended position, unless—

(1) A direct operating mechanism provides a sense of "feel" and position (such as when a mechanical linkage is employed); or

(2) The flap position is readily determined without seriously detracting from other piloting duties under any flight condition, day or night; and

(b) Flap installation with intermediate flap positions if—

(1) Any flap position other than retracted or fully extended is used to show compliance with the performance requirements of this part; and

(2) The flap installation does not meet the requirements of paragraph (a)(1) of this section.

(b) The airplane must be shown to have safe flight characteristics with any combination of extreme positions of individual movable surfaces (mechanically interconnected surfaces are to be considered as a single surface.)

(c) If an interconnection is used in multiengine airplanes, it must be designed to account for the unsymmetrical loads resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at takeoff power. For single-engine airplanes, and multiengine airplanes with no slipstream effects on the flaps, it may be assumed that 100 percent of the critical air load acts on one side and 70 percent on the other.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–42, Eff. 2/4/91)

## LANDING GEAR

### § 23.721 General.

For commuter category airplanes that have a passenger seating configuration, excluding pilot seats, of 10 or more, the following general requirements for the landing gear apply:

(a) The main landing-gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads to act in the upward and aft directions), the failure mode is not likely to cause the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.

(b) Each airplane must be designed so that, with the airplane under control, if can be landed on a paved runway with any one or more landing-gear legs not extended without sustaining a structural component failure that is likely to cause the spillage of enough fuel to constitute a fire hazard.

(c) Compliance with the provisions of this section may be shown by analysis or tests, or both.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87) ing weights.

(b) The landing gear may not fail, but may yield, in a test showing its reserved energy absorption capacity, simulating a descent velocity of 1.2 times the limit descent velocity, assuming wing lift equal to the weight of the airplane.

(Amdt. 23–23, Eff. 12/1/78)

### § 23.725 Limit drop tests.

(a) If compliance with § 23.723(a) is shown by free drop tests, these tests must be made on the complete airplane, or on units consisting of wheel, tire, and shock absorber, in their proper relation, from free drop heights not less than those determined by the following formula:

$$h \text{ (inches)} = 3.6 \, (W/S)^{1/2}$$

However, the free drop height may not be less than 9.2 inches and need not be more than 18.7 inches.

(b) If the effect of wing lift is provided for in free drop tests, the landing gear must be dropped with an effective weight equal to—

$$W_e = W \frac{h + (1-L)d}{h + d}$$

where—

$W_e$=the effective weight to be used in the drop test (lbs.);

$h$=specified free drop height (inches);

$d$=deflection under impact of the tire (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass (inches);

$W=W_M$ for main gear units (lbs.), equal to the static weight on that unit with the airplane in the level attitude (with the nose wheel clear in the case of the nose wheel type airplanes);

$W=W_T$ for tail gear units (lbs.), equal to the static weight on the tail unit with the airplane in the tail-down attitude;

$W=W_N$ for nose wheel units (lbs.), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0g downward and 0.33g forward; and

$L$=the ratio of the assumed wing lift to the airplane weight, but not more than 0.667.

(c) The limit inertia load factor must be determined in a rational or conservative manner, during

$$n = n_j \frac{W_e}{W} + L$$

where—

$n_j$=the load factor developed in the drop test (that is, the acceleration *(dv/dt)* in g's recorded in the drop test) plus 1.0; and

$W_e$, $W$, and $L$ are the same as in the drop test computation.

(f) The value of $n$ determined in accordance with paragraph (e) may not be more than the limit inertia load factor used in the landing conditions in § 23.473.

(Amdt. 23–7, Eff. 9/14/69)

### § 23.726 Ground load dynamic tests.

(a) If compliance with the ground load requirements of §§ 23.479 through 23.483 is shown dynamically by drop test, one drop test must be conducted that meets § 23.725 except that the drop height must be—

(1) 2.25 times the drop height prescribed in § 23.725(a); or

(2) Sufficient to develop 1.5 times the limit load factor.

(b) The critical landing condition for each of the design conditions specified in §§ 23.479 through 23.483 must be used for proof of strength.

(Amdt. 23–7, Eff. 9/14/69)

### § 23.727 Reserve energy absorption drop test.

(a) If compliance with the reserve energy absorption requirement in § 23.723(b) is shown by free drop tests, the drop height may not be less than 1.44 times that specified in § 23.725.

(b) If the effect of wing lift is provided for, the units must be dropped with an effective mass equal to $W_e = Wh/(h+d)$, when the symbols and other details are the same as in § 23.725.

(Amdt. 23–7, Eff. 9/14/69)

loads, occurring during retraction at any airspeed up to 1.6 $V_{S1}$, with flaps retracted, and for any load factor up to those specified in § 23.345 for the flaps-extended condition.

(2) The landing gear and retracting mechanism, including the wheel well doors, must withstand flight loads, including loads resulting from all yawing conditions specified in § 23.351, with the landing gear extended at any speed up to at least 1.6 $V_{S1}$ with the flaps retracted.

(b) *Landing gear lock.* There must be positive means (other than the use of hydraulic pressure) to keep the landing gear extended.

(c) *Emergency operation.* For a landplane having retractable landing gear that cannot be extended manually, there must be means to extend the landing gear in the event of either—

(1) Any reasonably probable failure in the normal landing gear operation system; or

(2) Any reasonably probable failure in a power source that would prevent the operation of the normal landing gear operation system.

(d) *Operation test.* The proper functioning of the retracting mechanism must be shown by operation tests.

(e) *Position indicator.* If a retractable landing gear is used, there must be a landing gear position indicator (as well as necessary switches to actuate the indicator) or other means to inform the pilot that the gear is secured in the extended (or retracted) position. If switches are used, they must be located and coupled to the landing gear mechanical system in a manner that prevents an erroneous indication of either "down and locked" if the landing gear is not in the fully extended position, or of "up and locked" if the landing gear is not in the fully retracted position. The switches may be located where they are operated by the actual landing gear locking latch or device.

(f) *Landing gear warning.* For landplanes, the following aural or equally effective landing gear warning devices must be provided:

(1) [A device that functions continuously when one or more throttles are closed beyond the power settings normally used for landing the warning device.

(2) [A device that functions continuously when the wing flaps are extended beyond the maximum approach flap position, using a normal landing procedure, if the landing gear is not fully extended and locked. There may not be a manual shutoff for this warning device. The flap position sensing unit may be installed at any suitable location. The system for this device may use any part of the system (including the aural warning device) for the device required in paragraph (f)(1) of this section.]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–26, Eff. 10/14/80); [(Amdt. 23–45, Eff. 9/7/93)]

## § 23.731 Wheels.

[(a)] The maximum static load rating of each wheel may not be less than the corresponding static ground reaction—

(1) Design maximum weight; and

(2) Critical center of gravity.

[(b)] The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this part.

[(Amdt. 23–45, Eff. 9/7/93)]

## § 23.733 Tires.

(a) [Each landing gear wheel must have a tire whose approved tire ratings (static and dynamic) are not exceeded—

(1) [By a load on each main wheel tire (to be compared to the static rating approved for such tires) equal to the corresponding static ground reaction under the design maximum weight and critical center of gravity; and

(2) [By a load on nose wheel tires (to be compared with the dynamic rating approved for such tires) equal to the reaction obtained at the nose wheel, assuming the mass of the airplane to be concentrated at the most critical center of gravity and exerting a force of 1.0$W$ downward and 0.31$W$ forward (where $W$ is the design maxi-

(c) Each tire installed on a retractable landing gear system must, at the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tire and any part of the structure of systems.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–17, Eff. 2/1/77); [(Amdt. 23–45, Eff. 9/7/93)]

### § 23.735 Brakes.

(a) Brakes must be provided so that the brake kinetic energy capacity rating of each main wheel brake assembly is not less than the kinetic energy absorption requirements determined under either of the following methods:

(1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during landing at the design landing weight.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula:

$$KE=0.0443\ WV^2/N$$

where—

*KE*=Kinetic energy per wheel (ft.-lb.);

*W*=Design landing weight (lb.);

*V*=Airplane speed in knots. V must be not less than $V_S\sqrt{}$, the poweroff stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and

*N*=Number of main wheels with brakes.

(b) Brakes must be able to prevent the wheels from rolling on a paved runway with takeoff power on the critical engine, but need not prevent movement of the airplane with wheels locked.

(c) If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction of failure will result in a hazardous loss of braking ability or directional control of the airplane.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–24, Eff. 12/31/79); (Amdt. 23–42, Eff. 2/4/91)

### 23.751 Main float buoyancy.

(a) Each main float must have—

(1) [A buoyancy of 80 percent in excess of the bouyancy required by that float to support its portion of the maximum weight of the seaplane or amphibian in fresh water; and

(2) [Enough watertight compartments to provide reasonable assurance that the seaplane or amphibian will stay afloat without capsizing if any two compartments of the main floats are flooded.]

(b) Each main float must contain at least four watertight compartments approximately equal in volume.

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.753 Main float design.

[Each seaplane main float must meet the requirements of § 23.521.]

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.755 Hulls.

(a) The hull of a hull seaplane or amphibian of 1,500 pounds or more maximum weight must have watertight compartments designed and arranged so that the hull, auxiliary floats, and tires (if used), will keep the airplane afloat [without capsizing] in fresh water when—

(1) For airplanes of 5,000 pounds or more maximum weight, any two adjacent compartments are flooded; and

(2) For airplanes of 1,500 pounds up to, but not including 5,000 pounds maximum weight, any single compartment is flooded.

(b) The hulls of hull seaplanes or amphibians of less than 1,500 pounds maximum weight need not be compartmented.

(c) Bulkheads with watertight doors may be used for communication between compartments.

[(Amdt. 23–45, Eff. 9/7/93)]

### § 23.771 Pilot compartment.

For each pilot compartment—

(a) The compartment and its equipment must allow each pilot to perform his duties without unreasonable concentration or fatigue;

(b) Where the flight crew are separated from the passengers by a partition, an opening or openable window or door must be provided to facilitate communication between flight crew and the passengers; and

(c) The aerodynamic controls listed in § 23.779, excluding cables and control rods, must be located with respect to the propellers so that no part of the pilot or the controls lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub making an angle of 5° forward or aft of the plane of rotation of the propeller.

(Amdt. 23–14, Eff. 12/20/73)

### § 23.773 Pilot compartment view.

[Each pilot compartment must be—

(1) Arranged with sufficiently extensive, clear and undistorted view to enable the pilot to safely taxi, takeoff, approach, land, and perform any maneuvers within the operating limitations of the airplane.

(2) Free from glare and reflections that could interfere with the pilot's vision. Compliance must be shown in all operations for which certification is requested; and

(3) Designed so that each pilot is protected from the elements so that moderate rain conditions do not unduly impair the pilot's view of the flight path in normal flight and while landing.

(b) Each pilot compartment must have a means to either remove or prevent the formation of fog or frost on an area of the internal portion of the windshield and side windows sufficiently large to provide the view specified in paragraph (a)(1) of this section. Compliance must be shown under all

(a) Nonsplintering safety glass must be used in internal glass panes.

(b) The design of windshields, windows, and canopies in pressurized airplanes must be based on factors peculiar to high altitude operation, including—

(1) The effects of continuous and cyclic pressurization loadings;

(2) The inherent characteristics of the material used; and

(3) The effects of temperatures and temperature gradients.

(c) On pressurized airplanes that do not comply with the fail-safe requirements of paragraph (e) of this section, an enclosure canopy including a representative part of the installation must be subjected to special tests to account for the combined effects of continuous and cyclic pressurization loadings and flight loads.

(d) The windshield and side windows forward of the pilot's back when he is seated in the normal flight position must have a luminous transmittance value of not less than 70 percent.

(e) If certification for operation above 25,000 feet is requested, the windshields, window panels, and canopies must be strong enough to withstand the maximum cabin pressure differential loads combined with critical aerodynamic pressure and temperature effects, after failure of any load-carrying element of the windshield, window panel, or canopy.

[(f) Unless operation in known or forecast icing conditions is prohibited by operating limitations, a means must be provided to prevent or to clear accumulations of ice from the windshield so that the pilot has adequate view for taxi, takeoff, approach, landing, and to perform any maneuvers within the operating limitations of the airplane.

[(g) In the event of any probable single failure, a transparency heating system must be incapable of raising the temperature of any windshield or window to a point where there would be—

(1) Structural failure that adversely affects the integrity of the cabin; or

(b) The controls must be located and arranged so that the pilot, when seated, has full and unrestricted movement of each control without interference from either his clothing or the cockpit structure.

(c) Powerplant controls must be located—

(1) For multiengine airplanes, on the pedestal or overhead at or near the center of the cockpit;

(2) For tandem seated single-engine airplanes, on the left side console or instrument panel;

(3) For other single-engine airplanes at or near the center of the cockpit, on the pedestal, instrument panel, or overhead; and

(4) For airplanes with side-by-side pilot seats and with two sets of powerplant controls, on left and right consoles.

(d) The control location order from left to right must be power (thrust) lever, propeller (rpm control), and mixture control (condition lever and fuel cutoff for turbine-powered airplanes). Power (thrust) levers must be at least one inch higher or longer to make them more prominent than propeller (rpm control) or mixture controls. Carburetor heat or alternate air control must be to the left of the throttle or at least eight inches from the mixture control when located other than on a pedestal. Carburetor heat or alternate air control, when located on a pedestal must be aft or below the power (thrust) lever. Supercharger controls must be located below or aft of the propeller controls. Airplanes with tandem seating or single-place airplanes may utilize control locations on the left side of the cabin compartment; however, location order from left to right must be power (thrust) lever, propeller (rpm control) and mixture control.

(e) Identical powerplant controls for each engine must be located to prevent confusion as to the engines they control.

(1) Conventional multiengine powerplant controls must be located so that the left control(s) operates the left engine(s) and the right control(s) operates the right engine(s).

(2) On twin-engine airplanes with front and rear engine locations (tandem), the left powerplant controls must operate the front engine and to the left of the throttle centerline or pedestal centerline.

(h) Each fuel feed selector control must comply with § 23.995 and be located and arranged so that the pilot can see and reach it without moving any seat or primary flight control then his seat is at any position in which it can be placed.

(1) For a mechnical fuel selector:

(i) The indication of the selected fuel valve position must be by means of a pointer and must provide positive identification and feel (detent, etc.) of the selected position.

(ii) The position indicator pointer must be located at the part of the handle that is the maximum dimension of the handle measured from the center of rotation.

(2) For electrical or electronic fuel selector:

(i) Digital controls or electrical switches must be properly labelled.

(ii) Means must be provided to indicate to the flight crew the tank or function selected. Selector switch position is not acceptable as a means of indication. The ''off' or ''closed'' position must be indicated in red.

(3) If the fuel valve selector handle or electrical or digital selection is also a fuel shut-off selector, the off position marking must be colored red. If a separate emergency shut-off means is provided, it also must be colored red.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–33, Eff. 8/11/86)

### § 23.779 Motion and effect of cockpit controls.

Cockpit controls must be designed so that they operate in accordance with the following movement and actuation:

(a) Aerodynamic controls:

| (1) *Primary controls:* | *Motion and effect* |
|---|---|
| Aileron .......... | Right (clockwise) for right wing down. |
| Elevator .......... | Rearward for nose up. |
| Rudder .......... | Right pedal forward for nose right. |

to the axis control. Axis of roll trim control may be displaced to accommodate comfortable actuation by the pilot. For single-engine airplanes, direction of pilot's hand movement must be in the same sense as airplane response for rudder trim if only a portion of a rotational element is accessible.

(b) Powerplant and auxiliary controls:

| (1) *Powerplant controls:* | *Motion and effect* |
| --- | --- |
| Power (thrust lever). | Forward to increase forward thrust and rearward to increase rearward thrust. |
| Propellers ....... | Forward to increase r.p.m. |
| Mixture .......... | Forward or upward for rich. |
| Carburetor, air heat or alternate air. | Forward or upward for cold. |
| Supercharger .. | Forward or upward for low blower. |
| Turbo-superchargers. | Forward, upward, or clockwise to increase pressure. |
| Rotary controls. | Clockwise from off to full on. |

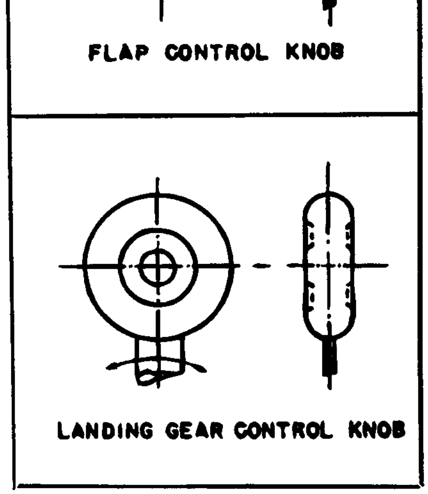
(2) *Auxiliary controls:*

| | |
| --- | --- |
| Fuel tank selector. | Right for right tanks, left for left tanks. |
| Landing gear. | Down to extend. |
| Speed brakes. | Aft to extend. |

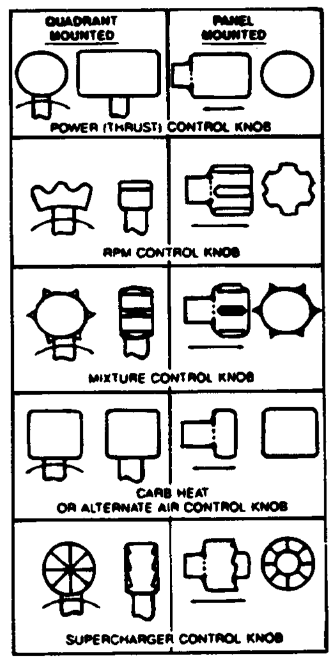
(Amdt. 23–33, Eff. 8/11/86)

### § 23.781 Cockpit control knob shape.

(a) Flap and landing gear control knobs must conform to the general shapes (but not necessarily the exact sizes or specific proportions) in the following figure:




(b) Powerplant control knobs must conform to the general shapes (but not necessarily the exact sizes of specific proportions) in the following figure:




(Amdt. 23–33, Eff. 8/11/86)

(1) There must be means to lock and safeguard the door against inadvertent opening during flight by persons, by cargo, or as a result of mechanical failure.

(2) The door must be openable from the inside and the outside when the internal locking mechanism is in the locked position.

(3) There must be a means of opening which is simple and obvious and is arranged and marked inside and outside so that the door can be readily located, unlocked, and opened, even in darkness.

(4) The door must meet the marking requirements of § 23.811 of this part.

(5) The door must be reasonably free from jamming as a result of fuselage deformation in an emergency landing.

(6) Auxiliary locking devices that are actuated externally to the airplane may be used but such devices must be overridden by the normal internal opening means.

(d) In addition, each external passenger or crew door, for a commuter category airplane, must comply with the following requirements:

(1) Each door must be openable from both the inside and outside, even though persons may be crowded against the door on the inside of the airplane.

(2) If inward opening doors are used, there must be a means to prevent occupants from crowding against the door to the extent that would interfere with opening the door.

(3) Auxiliary locking devices may be used.

(e) Each external door on a commuter category airplane, each external door forward of any engine or propeller on a normal, utility, or acrobatic category airplane, and each door of the pressure vessel on a pressurized airplane must comply with the following requirements:

(1) There must be a means to lock and safeguard each external door, including cargo and service type doors, against inadvertent opening in flight, by persons, by cargo, or as a result of mechanical failure or failure of a single structural element, either during or after closure.

to signal a flight crewmember if the external door is not fully closed and locked. The means must be designed so that any failure, or combination of failures, that would result in an erroneous closed and locked indication is improbable for doors for which the initial opening movement is not inward.

**[**(f) In addition, for commuter category airplanes, the following requirements apply:

**[**(1) Each passenger entry door must qualify as a floor level emergency exit. This exit must have a rectangular opening of not less than 24 inches wide by 48 inches high, with corner radii not greater than one-third the width of the exit.

**[**(2) If an integral stair is installed at a passenger entry door, the stair must be designed so that, when subjected to the inertia loads resulting from the ultimate static load factors in § 23.561(b)(2) and following the collapse of one or more legs of the landing gear, it will not reduce the effectiveness of emergency egress through the passenger entry door.**]**

(Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–36, Eff. 9/14/88); **[**(Amdt. 23–46, Eff. 6/16/94)**]**

### § 23.785 Seats, berths, litters, safety belts, and shoulder harnesses.

(a) Each seat/restraint system and the supporting structure must be designed to support occupants weighing at least 215 pounds when subjected to the maximum load factors corresponding to the specified flight and ground load conditions, as defined in the approved operating envelope of the airplane. In addition, these loads must be multiplied by a factor of 1.33 in determining the strength of all fittings and the attachment of—

(1) Each seat to the structure; and

(2) Each safety belt and shoulder harness to the seat or structure.

(b) Each forward-facing or aft-facing seat/restraint system in normal, utility, or acrobatic category airplanes must consist of a seat, safety belt, and shoulder harness that are designed to provide the occupant protection provisions required in § 23.562 of this part. Other seat orientations must of this part, and each occupant must be protected from serious head injury when subjected to the inertia loads resulting from these load factors by a safety belt and shoulder harness for the front seats; and a safety belt, or a safety belt and shoulder harness, for each seat other than the front seats,

(d) Each restraint system must have a single-point release for occupant evacuation.

(e) The restraint system for each crewmember must allow the crewmember, when seated with the safety belt and shoulder harness fastened, to perform all functions necessary for flight operations.

(f) Each pilot seat must be designed for the reactions resulting from the application of pilot forces to the primary flight controls as prescribed in § 23.395 of this part.

(g) There must be a means to secure each safety belt and shoulder harness, when not in use, to prevent interference with the operation of the airplane and with rapid occupant egress in an emergency.

(h) Unless otherwise placarded, each seat in a utility or acrobatic category airplane must be designed to accommodate an occupant wearing a parachute.

(i) The cabin area surrounding each seat, including the structure, interior walls, instrument panel, control wheel, pedals, and seats within striking distance of the occupant's head or torso (with the restraint system fastened) must be free of potentially injurious objects, sharp edges, protuberances, and hard surfaces. If energy absorbing designs or devices are used to meet this requirement, they must protect the occupant from serious injury when the occupant is subjected to the inertia loads resulting from the ultimate static load factors prescribed in § 23.561(b)(2) of this part, or they must comply with the occupant protection provisions of § 23.562 of this part, as required in paragraphs (b) and (c) of this section.

(j) Each seat track must be fitted with stops to prevent the seat from sliding off the track.

(k) Each seat/restraint system may use design features, such as crushing or separation of certain components, to reduce occupant loads when showing compliance with the requirements of § 23.562 that can withstand the load reactions from a 215-pound occupant when subjected to the inertia loads resulting from the ultimate static load factors of § 23.561(b)(2) of this part. In addition—

(1) Each berth or litter must have an occupant restraint system and may not have corners or other parts likely to cause serious injury to a person occupying it during emergency landing conditions; and

(2) Occupant restraint system attachments for the berth or litter must withstand the inertia loads resulting from the ultimate static load factors of § 23.561(b)(2) of this part.

(n) Proof of compliance with the static strength requirements of this section for seats and berths approved as part of the type design and for seat and berth installations may be shown by—

(1) Structural analysis, if the structure conforms to conventional airplane types for which existing methods of analysis are known to be reliable;

(2) A combination of structural analysis and static load tests to limit load; or

(3) Static load tests to ultimate loads.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–19, Eff. 7/18/77); (Amdt. 23–23, Eff. 12/1/78); (Amdt. 23–32, Eff. 12/12/85); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–36, Eff. 9/14/88)

### § 23.787 Baggage and cargo compartments.

(a) Each cargo compartment must be designed for its placarded maximum weight of contents and for the critical load distributions at the appropriate maximum load factors corresponding to the flight and ground load conditions of this part.

(b) There must be means to prevent the contents of any cargo compartment from becoming a hazard by shifting, and to protect any controls, wiring, lines, equipment or accessories whose damage or failure would affect safe operations.

(c) There must be a means to protect occupants from injury by the contents of any baggage or cargo compartment, located aft of the occupants and separated by structure, when the ultimate forward inertia load factor is 9g and assuming the factors of § 23.561(b)(3) of this part, assuming the maximum allowed baggage or cargo weight for the compartment.

(f) If cargo compartment lamps are installed, each lamp must be installed so as to prevent contact between lamp bulb and cargo.

(g) Baggage compartments used in computer category airplanes must also meet the requirements of paragraphs (a), (b), (d), and (f) of this section.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–17, Eff. 2/1/77); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–36, Eff. 9/14/88)

### § 23.803 Emergency evacuation.

[(a)] For commuter category airplanes, an evacuation demonstration must be conducted utilizing the maximum number of occupants for which certification is desired. The demonstration must be conducted under simulated night conditions using only the emergency exits on the most critical side of the airplane. The participants must be representative of average airline passengers with no prior practice or rehearsal for the demonstration. Evacuation must be completed within 90 seconds.

[(b) In addition, when certification to the emergency exit provisions of § 23.807(d)(4) is requested, only the emergency lighting system required by § 23.812 may be used to provide cabin interior illumination during the evacuation demonstration required in paragraph (a) of this section.]

(Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–46, Eff. 6/16/94)]

### [§ 23.805 Flightcrew emergency exits.

[For airplanes where the proximity of the passenger emergency exits to the flightcrew area does not offer a convenient and readily accessible means of evacuation for the flightcrew, the following apply:

[(a) There must be either one emergency exit on each side of the airplane, or a top hatch emergency exit, in the flightcrew area;

[(b) Each emergency exit must be located to allow rapid evacuation of the crew and have a

[(1) Attached to the fuselage structure at or above the top of the emergency exit opening or, for a device at a pilot's emergency exit window, at another approved location if the stowed device, or its attachment, would reduce the pilot's view; and

[(2) Able (with its attachment) to withstand a 400-pound static load.]

[(Amdt. 23–46, Eff. 6/16/94)]

### § 23.807 Emergency exits.

(a) *Number and location.* Emergency exits must be located to allow escape without crowding in any probable crash attitude. The airplane must have at least the following emergency exits:

(1) For all airplanes with a seating capacity of two or more, excluding airplanes with canopies, at least one emergency exit on the opposite side of the cabin from the main door specified in § 23.783 of this part.

(2) [Reserved]

(3) If the pilot compartment is separated from the cabin by a door that is likely to block the pilot's escape in a minor crash, there must be an exit in the pilot's compartment. The number of exits required by paragraph (a)(1) of this section must then be separately determined for the passenger compartment, using the seating capacity of that compartment.

(b) *Type and operation.* Emergency exits must be movable windows, panels, canopies, or external doors, openable from both inside and outside the airplane, that provide a clear and unobstructed opening large enough to admit a 19-by-26-inch ellipse. Auxiliary locking devices used to secure the airplane must be designed to be overridden by the normal internal opening means. In addition, each emergency exit must—

(1) Be readily accessible, requiring no exceptional agility to be used in emergencies;

(2) Have a method of opening that is simple and obvious;

(3) Be arranged and marked for easy location and operation, even in darkness;

apply:

(1) [In addition to the passenger-entry door—

[(i) For an airplane with a total passenger seating capacity of 15 or fewer, an emergency exit, as defined in paragraph (b) of this section, is required on each side of the cabin; and

[(ii) For an airplane with a total passenger seating capacity of 16 through 19, three emergency exits, as defined in paragraph (b) of this section, are required with one on the same side as the passenger entry door and two on the side opposite the door.]

(2) A means must be provided to lock each emergency exit and to safeguard against its opening in flight, either inadvertently by persons or as a result of mechanical failure. In addition, a means for direct visual inspection of the locking mechanism must be provided to determine that each emergency exit for which the initial opening movement is outward is fully locked.

[(3) Each required emergency exit, except floor level exits, must be located over the wing or, if not less than six feet from the ground, must be provided with an acceptable means to assist the occupants to descend to the ground. Emergency exits must be distributed as uniformly as practical, taking into account passenger seating configuration.

[(4) Unless the applicant has complied with paragraph (d)(1) of this section, there must be an emergency exit on the side of the cabin opposite the passenger entry door, provided that—

[(i) For an airplane having a passenger seating configuration of nine or fewer, the emergency exit has a rectangular opening measuring not less than 19 inches by 26 inches high with corner radii not greater than one-third the width of the exit, located over the wing, with a step up inside the airplane of not more than 29 inches and a step down outside the airplane of not more than 36 inches;

[(ii) For an airplane having a passenger seating configuration of 10 to 19 passengers, the emergency exit has a rectangular opening measuring not less than 20 inches wide by

23.815.

[(e) For multiengine airplanes, ditching emergency exits must be provided in accordance with the following requirements, unless the emergency exits required by paragraph (a) or (d) of this section already comply with them:

[(1) One exit above the waterline on each side of the airplane having the dimensions specified in paragraph (b) or (d) of this section, as applicable; and

[(2) If side exits cannot be above the waterline, there must be a readily accessible overhead hatch emergency exit that has a rectangular opening measuring not less than 20 inches wide by 36 inches long, with corner radii not greater than one-third the width of the exit.]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–10, Eff. 3/13/71); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–36, Eff. 9/14/88); [(Amdt. 23–46, Eff. 6/16/94)]

### § 23.811 Emergency exit marking.

(a) Each emergency exit and external door in the passenger compartment must be externally marked and readily identifiable from outside the airplane by—

(1) A conspicuous visual identification scheme; and

(2) A permanent decal or placard on or adjacent to the emergency exit which shows the means of opening the emergency exit, including any special instructions, if applicable.

(b) In addition, for commuter category airplanes, these exits and doors must be internally marked with the word ''exit'' by a sign which has white letters 1 inch high on a red background 2 inches high, be self-illuminated or independently, internally-electrically illuminated, and have a minimum brightness of at least 160 microlamberts. The color may be reversed if the passenger compartment illumination is essentially the same.

[(c) In addition, when certification to the emergency exit provisions of § 23.807(d)(4) is requested, the following apply:

[(4) The location of the operating handle and instructions for opening each emergency exit from inside the airplane must be shown by marking that is readable from a distance of 30 inches;

[(5) Each passenger entry door operating handle must—

[(i) Be self-illuminated with an initial brightness of at least 160 microlamberts; or

[(ii) Be conspicuously located and well illuminated by the emergency lighting even in conditions of occupant crowding at the door;

(6) Each passenger entry door with a locking mechanism that is released by rotary motion of the handle must be marked—

[(i) With a red arrow, with a shaft of at least three-fourths of an inch wide and a head twice the width of the shaft, extending along at least 70 degrees of arc at a radius approximately equal to three-fourths of the handle length;

[(ii) So that the center line of the exit handle is within ± one inch of the projected point of the arrow when the handle has reached full travel and has released the locking mechanism; and

[(iii) With the word "open" in red letters, one inch high, placed horizontally near the head of the arrow; and

[(7) In addition to the requirements of paragraph (a) of this section, the external marking of each emergency exit must—

[(i) Include a 2-inch colorband outlining the exit; and

[(ii) Have a color contrast that is readily distinguishable from the surrounding fuselage surface. The contrast must be such that if the reflectance of the darker color is 15 percent or less, the reflectance of the lighter color must be at least 45 percent. "Reflectance" is the ratio of the luminous flux reflected by a body to the luminous flux it receives. When the reflectance of the darker color is greater than 15 percent, at least a 30 percent difference apply:

[(a) An emergency lighting system, independent of the main cabin lighting system, must be installed. However, the source of general cabin illumination may be common to both the emergency and main lighting systems if the power supply to the emergency lighting system is independent of the power supply to the main lighting system.

[(b) There must be a crew warning light that illuminates in the cockpit when power is on in the airplane and the emergency lighting control device is not armed.

[(c) The emergency lights must be operable manually from the flightcrew station and be provided with automatic activation. The cockpit control device must have "on," "off," and "armed" positions so that, when armed in the cockpit, the lights will operate by automatic activation.

[(d) There must be a means to safeguard against inadvertent operation of the cockpit control device from the "armed" or "on" positions.

[(e) The cockpit control device must have provisions to allow the emergency lighting system to be armed or activated at any time that it may be needed.

[(f) When armed, the emergency lighting system must activate and remain lighted when—

[(1) The normal electrical power of the airplane is lost; or

[(2) The airplane is subjected to an impact that results in a deceleration in excess of 2g and a velocity change in excess of 3.5 feet-per-second, acting along the longitudinal axis of the airplane; or

[(3) Any other emergency condition exists where automatic activation of the emergency lighting is necessary to aid with occupant evacuation.

[(g) The emergency lighting system must be capable of being turned off and reset by the flightcrew after automatic activation.

[(h) The emergency lighting system must provide internal lighting, including—

and

[(3) Floor proximity emergency escape path marking that provides emergency evacuation guidance for the airplane occupants when all sources of illumination more than 4 feet above the cabin aisle floor are totally obscured.

[(i) The energy supply to each emergency lighting unit must provide the required level of illumination for at least 10 minutes at the critical ambient conditions after activation of the emergency lighting system.

[(j) If rechargeable batteries are used as the energy supply for the emergency lighting system, they may be recharged from the main electrical power system of the airplane provided the charging circuit is designed to preclude inadvertent battery discharge into the charging circuit faults. If the emergency lighting system does not include a charging circuit, battery condition monitors are required.

[(k) Components of the emergency lighting system, including batteries, wiring, relays, lamps, and switches, must be capable of normal operation after being subjected to the inertia forces resulting from the ultimate load factors prescribed in § 23.561(b)(2).

[(l) The emergency lighting system must be designed so that after any single transverse vertical separation of the fuselage during a crash landing:

[(1) At least 75 percent of all electrically illuminated emergency lights required by this section remain operative; and

[(2) Each electrically illuminated exit sign required by § 23.811(b) and (c) remains operative, except those that are directly damaged by the fuselage separation.]

[(Amdt. 23–46, Eff. 6/16/94)]

### § 23.813 Emergency exit access.

[(a)] For commuter category airplanes, access to window-type emergency exits may not be obstructed by seats or seat backs.

[(b) In addition, when certification to the emergency exit provisions of § 23.807(d)(4) is requested, inches.

[(3) If it is necessary to pass through a passageway between passenger compartments to reach a required emergency exit from any seat in the passenger cabin, the passageway must be unobstructed; however, curtains may be used if they allow free entry through the passageway.

[(4) No door may be installed in any partition between passenger compartments unless that door has a means to latch it in the open position. The latching means must be able to withstand the loads imposed upon it by the door when the door is subjected to the inertia loads resulting from the ultimate static load factors prescribed in § 23.561(b)(2).

[(5) If it is necessary to pass through a doorway separating the passenger cabin from other areas to reach a required emergency exit from any passenger seat, the door must have a means to latch it in the open position. The latching means must be able to withstand the loads imposed upon it by the door when the door is subjected to the inertia loads resulting from the ultimate static load factors prescribed in § 23.561(b)(2).]

(Amdt. 23–36, Eff. 9/14/88); [(Amdt. 23–46, Eff. 6/16/94)]

### § 23.815 Width of aisle.

[(a) Except as provided in paragraph (b) of this section, for] commuter category airplanes, the width of the main passenger aisle at any point between seats must equal or exceed the values in the following table:

| Number of Passenger Seats | Minimum main passenger aisle width | |
|---|---|---|
| | Less than 25 inches from floor | 25 inches and more from floor |
| 10 through 19 | 9 inches | 15 inches |

[(b) When certification to the emergency exit provisions of § 23.807(d)(4) is requested, the main passenger aisle width at any point between the seats must equal or exceed the following values:

(Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–46, Eff. 6/16/94)]

### § 23.831 Ventilation.

(a) Each passenger and crew compartment must be suitably ventilated. Carbon monoxide concentration may not exceed one part in 20,000 parts of air.

(b) For pressurized airplanes, the ventilating air in the flightcrew and passenger compartments must be free of harmful or hazardous concentrations of gases and vapors in normal operations and in the event of reasonably probable failures or malfunctioning of the ventilating, heating, pressurization, or other systems and equipment. If accumulation of hazardous quantities of smoke in the cockpit area is reasonably probable, smoke evacuation must be readily accomplished starting with full pressurization and without depressurizing beyond safe limits.

(Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–42, Eff. 2/4/91)

## PRESSURIZATION

### § 23.841 Pressurized cabins.

(a) If certification for operation over 31,000 feet is requested, the airplane must be able to maintain a cabin pressure altitude of not more than 15,000 feet in event of any probable failure or malfunction in the pressurization system.

(b) Pressurized cabins must have at least the following valves, controls, and indicators, for controlling cabin pressure:

(1) Two pressure relief valves to automatically limit the positive pressure differential to a predetermined valve at the maximum rate of flow delivered by the pressure source. The combined capacity of the relief valves must be large enough so that the failure of any one valve would not cause an appreciable rise in the pressure differential. The pressure differential is positive when the internal pressure is greater than the external.

controlling the intake or exhaust airflow, or both, for maintaining the required internal pressures and airflow rates.

(5) Instruments to indicate to the pilot the pressure differential, the cabin pressure altitude, and the rate of change of cabin pressure altitude.

(6) Warning indication at the pilot station to indicate when the safe or preset pressure differential is exceeded and when a cabin pressure altitude of 10,000 feet is exceeded.

(7) A warning placard for the pilot if the structure is not designed for pressure differentials up to the maximum relief valve setting in combination with landing loads.

(8) A means to stop rotation of the compressor or to divert airflow from the cabin if continued rotation of an engine-driven cabin compressor or continued flow of any compressor bleed air will create a hazard if a malfunction occurs.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–17, Eff. 2/1/77)

### § 23.843 Pressurization tests.

(a) *Strength test.* The complete pressurized cabin, including doors, windows, canopy, and valves, must be tested as a pressure vessel for the pressure differential specified in § 23.365(d).

(b) *Functional tests.* The following functional tests must be performed:

(1) Tests of the functioning and capacity of the positive and negative pressure differential valves, and of the emergency release valve, to simulate the effects of closed regulator valves.

(2) Tests of the pressurization system to show proper functioning under each possible condition of pressure, temperature, and moisture, up to the maximum altitude for which certification is requested.

(3) Flight tests, to show the performance of the pressure supply, pressure and flow regulators, indicators, and warning signals, in steady and stepped climbs and descents at rates corresponding to the maximum attainable within the operating limitations of the airplane, up to the maximum altitude for which certification is requested.

[(a) There must be at least one hand fire extinguisher for use in the pilot compartment that is located within easy access of the pilot while seated.

(b) There must be at least one hand fire extinguisher located conveniently in the passenger compartment.—

(1) Of each airplane accommodating more than 6 passengers; and

(2) Of each commuter category airplane.

(c) For hand fire extinguishers, the following apply:

(1) The type and quantity of each extinguishing agent used must be appropriate to the kinds of fire likely to occur where that agent is to be used.

(2) Each extinguisher for use in a personnel compartment must be designed to minimize the hazard of toxic gas concentrations.]

(Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

### § 23.853 Compartment interiors.

For each compartment to be used by the crew or passengers—

(a) The materials must be at least flame resistant;

(b) [Reserved]

(c) If smoking is to be prohibited, there must be a placard so stating, and if smoking is to be allowed—

(1) There must be an adequate number of self-contained, removable ashtrays; and

(2) Where the crew compartment is separated from the passenger compartment, there must be at least one illuminated sign (using either letters or symbols) notifying all passengers when smoking is prohibited. Signs which notify when smoking is prohibited must—

(i) When illuminated, be legible to each passenger seated in the passenger cabin under all probable lighting conditions; and

(ii) Be so constructed that the crew can turn the illumination on and off.

(d) In addition, for commuter category airplanes the following requirements apply:

must be located on or near each disposal receptacle door.

(2) Lavatories must have "No Smoking" or "No Smoking in Lavatory" placards located conspicuously on each side of the entry door and self-contained, removable ashtrays located conspicuously on or near the entry side of each lavatory door, except that one ashtray may serve more than one lavatory door if it can be seen from the cabin side of each lavatory door served. The placards must have red letters at least ½ inch high on a white background at least 1 inch high (a "No Smoking" symbol may be included on the placard).

(3) Materials (including finishes or decorative surfaces applied to the materials) used in each compartment occupied by the crew or passengers must meet the following test criteria as applicable:

(i) Interior ceiling panels, interior wall panels, partitions, galley structure, large cabinet walls, structural flooring, and materials used in the construction of stowage compartments (other than underseat stowage compartments and compartments for stowing small items such as magazines and maps) must be self-extinguishing when tested vertically in accordance with the applicable portions of appendix F of this part or by other equivalent methods. The average burn length may not exceed 6 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 3 seconds after falling.

(ii) Floor covering, textiles (including draperies and upholstery), seat cushions, padding, decorative and nondecorative coated fabrics, leather, trays and galley furnishings, electrical conduit, thermal and acoustical insulation and insulation covering, air ducting, joint and edge covering, cargo compartment liners, insulation brakes, cargo covers and transparencies, molded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing), that are constructed of materials not covered than an average of 3 seconds after falling.

(iii) Motion picture film must be safety film meeting the Standard Specifications for Safety Photographic Film PH1.25 (available from the American National Standards Institute, 1430 Broadway, New York, NY 10018) or an FAA approved equivalent). If the film travels through ducts, the ducts must meet the requirements of paragraph (d)(3)(ii) of this section.

(iv) Acrylic windows and signs, parts constructed in whole or in part of elastomeric materials, edge-lighted instrument assemblies consisting of two or more instruments in a common housing, seatbelts, shoulder harnesses, and cargo and baggage tiedown equipment, including containers, bins, pallets, etc., used in passenger or crew compartments, may not have an average burn rate greater than 2.5 inches per minute when tested horizontally in accordance with the applicable portions of appendix F of this part or by other approved equivalent methods.

(v) Except for electrical wire cable insulation, and for small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts) that the Administrator finds would not contribute significantly to the propagation of a fire, materials in items not specified in (d)(3)(i), (ii), (iii), or (iv) of this section may not have a burn rate greater than 4.0 inches per minute when tested horizontally in accordance with the applicable portions of appendix F of this part or by other approved equivalent methods.

(e) Lines, tanks, or equipment containing fuel, oil, or other flammable fluids may not be installed in such compartments unless adequately shielded, isolated, or otherwise protected so that any breakage or failure of such an item would not create a hazard.

(f) Airplane materials located on the cabin side of the firewall must be self-extinguishing or be located at such a distance from the firewall, or otherwise protected, so that ignition will not occur if the firewall is subjected to a flame temperature of not less than 2,000° F for 15 minutes. For self-extinguishing materials (except electrical wire and cable insulation and small parts that the Administrator finds would not contribute significantly to the propagation of a fire), a vertical self-extinguishing test must be conducted in accordance with appendix F of this part or an equivalent method approved by the Administrator. The average burn length of the material may not exceed 6 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the material test specimen may not continue to flame for more than an average of 3 seconds after falling.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–23, Eff. 12/1/78); (Amdt. 23–25, Eff. 3/6/80); (Amdt. 23–34, Eff. 2/17/87)

## § 23.859 Combustion heater fire protection.

(a) *Combustion heater fire regions.* The following combustion heater fire regions must be protected from fire in accordance with the applicable provisions of §§ 23.1182 through 23.1191 and 23.1203:

(1) The region surrounding the heater, if this region contains any flammable fluid system components (excluding the heater fuel system) that could—

(i) Be damaged by heater malfunctioning; or

(ii) Allow flammable fluids or vapors to reach the heater in case of leakage.

(2) The region surrounding the heater, if the heater fuel system has fittings that, if they leaked, would allow fuel vapor to enter this region.

(3) The part of the ventilating air passage that surrounds the combustion chamber.

(b) *Ventilating air ducts.* Each ventilating air duct passage through any fire region must be fireproof. In addition—

(1) Unless isolation is provided by fireproof valves or by equally effective means, the ventilating air duct downstream of each heater must be fireproof for a distance great enough to ensure that any fire originating in the heater can be contained in the duct; and

(2) Each part of any ventilating duct passing through any region having a flammable fluid system must be constructed or isolated from that system so that the malfunctioning of any component of that system cannot introduce flammable fluids or vapors into the ventilating airstream.

(c) *Combustion air ducts.* Each combustion air duct must be fireproof for a distance great enough to prevent damage from backfiring or reverse flame propagation. In addition—

could cause heater failure.

(d) *Heater controls: general.* Provision must be made to prevent the hazardous accumulation of water or ice on or in any heater control component, control system tubing, or safety control.

(e) *Heater safety controls.*

(1) Each combustion heater must have the following safety controls:

(i) Means independent of the components for the normal continuous control of air temperature, airflow, and fuel flow must be provided to automatically shut off the ignition and fuel supply to that heater at a point remote from that heater when any of the following occurs:

(A) The heat exchanger temperature exceeds safe limits.

(B) The ventilating air temperature exceeds safe limits.

(C) The combustion airflow becomes inadequate for safe operation.

(D) The ventilating airflow becomes inadequate for safe operation.

(ii) Means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means prescribed in paragraph (e)(1)(i) of this section.

(2) The means for complying with paragraph (e)(1)(i) of this section for any individual heater must—

(i) Be independent of components serving any other heater whose heat output is essential for safe operations; and

(ii) Keep the heater off until restarted by the crew.

(f) *Air intakes.* Each combustion and ventilating air intake must be located so that no flammable fluids or vapors can enter the heater system under any operating condition—

(1) During normal operation; or

(2) As a result of the malfunctioning of any other component.

(g) *Heater exhaust.* Heater exhaust systems must meet the provisions of §§ 23.1121 and 23.1123. In addition, there must be provisions in the design

flammable fluid lines; and

(4) Restrictions in the exhaust system to relieve backfires that, if so restricted, could cause heater failure.

(h) *Heater fuel systems.* Each heater fuel system must meet each powerplant fuel system requirement affecting safe heater operation. Each heater fuel system component within the ventilating airstream must be protected by shrouds so that no leakage from those components can enter the ventilating airstream.

(i) *Drains.* There must be means to safely drain fuel that might accumulate within the combustion chamber or the heater exchanger. In addition—

(1) Each part of any drain that operates at high temperatures must be protected in the same manner as heater exhausts; and

(2) Each drain must be protected from hazardous ice accumulation under any operating condition.

(Amdt. 23–5, Eff. 6/4/67); (Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–27, Eff. 11/19/80)

### § 23.863 Flammable fluid fire protection.

(a) In each area where flammable fluids or vapors might escape by leakage of a fluid system, there must be means to minimize the probability of ignition of the fluids and vapors, and the resultant hazard if ignition does occur.

(b) Compliance with paragraph (a) of this section must be shown by analysis or tests, and the following factors must be considered:

(1) Possible sources and paths of fluid leakage, and means of detecting leakage.

(2) Flammability characteristics of fluids, including effects of any combustible or absorbing materials.

(3) Possible ignition sources, including electrical faults, overheating of equipment, and malfunctioning of protective devices.

(4) Means available for controlling or extinguishing a fire, such as stopping flow of fluids, shutting down equipment, fireproof containment, or use of extinguishing agents.

be identified and defined.

(Amdt. 23–23, Eff. 12/1/78)

### § 23.865 [Fire protection of flight controls, engine mounts, and other flight structure.

[Flight controls, engine mounts, excluding those portions that are certificated as part of the engine, and other flight structure located in the engine compartment must be constructed of fireproof material or shielded so that they are capable of withstanding the effects of a fire. Engine vibration isolators must incorporate suitable features to ensure that the engine is retained if the non-fireproof portions of the isolators deteriorate from the effects of a fire.]

(Amdt. 23–14, Eff. 12/20/73); [(Amdt. 23–45, Eff. 9/7/93)]

airframe; or

(2) Designing the components so that a strike will not endanger the airplane.

(c) For nonmetallic components, compliance with paragraph (a) of this section may be shown by—

(1) Designing the components to minimize the effect of a strike; or

(2) Incorporating acceptable means of diverting the resulting electrical current so as not to endanger the airplane.

(Amdt. 23–7, Eff. 9/14/69)

## MISCELLANEOUS

### § 23.871 Leveling means.

There must be means for determining when the airplane is in a level position on the ground.

(Amdt. 23–7, Eff. 9/14/69)

at $V_C$ or $V_A$ using the basic airfoil moment coefficient modified over the aileron portion of the span, must be computed as follows:

(i) $C_m = C_m + 0.01\delta_u$ (up aileron side) wing basic airfoil.

(ii) $C_m = C_m - 0.01\delta_u$ (down aileron side) wing basic airfoil, where $\delta_u$ is the up aileron deflection and $\delta_d$ is the down aileron deflection.

(4) $\Delta$ critical, which is the sum of $\delta_u+\delta_d$, must be computed as follows:

(i) Compute $\Delta_a$ and $\Delta_b$ from the formulas:

$$\Delta_a = \frac{V_A}{V_C} \times \Delta_p$$

and

$$\Delta_b = 0.5 \frac{V_A}{V_D} \times \Delta_p$$

where—

$\Delta_p$=the maximum total deflection (sum of both aileron deflections) at $V_A$ with $V_A$, $V_C$, and $V_D$ described in subparagraph (2) of § 23.7(e) of this appendix.

(ii) Compute $K$ from the formula:

$$K = \frac{(C_m - 0.01\delta_b)V_D^2}{(C_m - 0.01\delta_a)V_C^2}$$

where—

$\delta_a$ is the down aileron deflection corresponding to $\Delta_a$ and $\delta_b$ is the down aileron deflection corresponding to $\Delta_b$, as computed in step (i).

(iii) If $K$ is less than 1.0, $\Delta_a$, is $\Delta$ critical and must be used to determine $\delta_u$, and $\delta_d$, In this case, $V_C$ is the critical speed which must be used in computing the wing torsion loads over the aileron span.

(iv) If $K$ is equal to or greater than 1.0, $\Delta_b$, is $\Delta$, critical and must be used to determine $\delta_u$, and $\delta_d$. In this case, $V_D$ is the critical speed which must be used in computing the wing torsion loads over the aileron span.

(d) *Supplementary conditions; rear lift truss; engine torque; side load on engine mount.* Each ... the maximum gross weight.

(2) Each engine mount and its supporting structures must be designed for the maximum limit torque corresponding to METO power and propeller speed acting simultaneously with the limit loads resulting from the maximum positive maneuvering flight load factor $n_1$. The limit torque must be obtained by multiplying the mean torque by a factor of 1.33 for engines with five or more cylinders. For 4-, 3-, and 2-cylinder engines, the factor must be 2, 3, and 4, respectively.

(3) Each engine mount and its supporting structure must be designed for the loads resulting from a lateral limit load factor of not less than 1.47 for the normal and utility categories, or 2.0 for the acrobatic category.

**A23.11 Control surface loads.**

(a) *General.* Each control surface load must be determined using the criteria of paragraph (b) of this section and must lie within the simplified loadings of paragraph (c) of this section.

(b) *Limit pilot forces.* In each control surface loading condition described in paragraphs (c) through (e) of this section, the airloads on the movable surfaces and the corresponding deflections need not exceed those which could be obtained in flight by employing the maximum limit pilot forces specified in the table in § 23.397(b). If the surface loads are limited by these maximum limit pilot forces, the tabs must either be considered to be deflected to their maximum travel in the direction which would assist the pilot or the deflection must correspond to the maximum degree of ''out of trim'' expected at the speed for the condition under consideration. The tab load, however, need not exceed the value specified in table 2 of this appendix.

(c) *Surface loading conditions.* Each surface loading condition must be investigated as follows:

(1) Simplified limit surface loadings and distributions for the horizontal tail, vertical tail, aileron, wing flaps, and trim tabs are specified in table 2 and figures 5 and 6 of this appendix.

(e) *Special devices.* Special devices must meet the requirements of § 23.459.

### A23.13 Control system loads.

(a) Primary flight controls and systems. Each primary flight control and system must be designed as follows:

(1) The flight control system and its supporting structure must be designed for loads corresponding to 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in A23.11 of this appendix. In addition—

(i) The system limit loads need not exceed those that could be produced by the pilot and automatic devices operating the controls; and

flight conditions, and to be reacted at the attachments of the control system to the control surface horn.

(b) *Dual controls.* If there are dual controls, the systems must be designed for pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with paragraph (a) of this section, except that individual pilot loads may not be less than the minimum limit pilot forces shown in the table in § 23.397(b).

(c) *Ground gust conditions.* Ground gust conditions must meet the requirements of § 23.415.

(d) *Secondary controls and systems.* Secondary controls and systems must meet the requirements of § 23.405.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–16, Eff. 2/14/75); (Amdt. 23–28, Eff. 4/28/82)